POLICY ANALYSIS OF ENERGY-ECONOMY INTERACTIONS IN MEXICO:
A Multiperiod Optimizing General Equilibrium Model.

Ricardo Manuel Barba-Viniegra

Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

Department of Economics
University of Warwick

September 1989.

CONTENTS.

LIST OF TABLES.

LIST OF FIGURES.

A PAULINA

A MIS PADRES,
ABUELA Y HERMANOS

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Professor Graham Pyatt for his interest and encouragement. His guidance and suggestions were invaluable for the development of this research.

I also would like to thank Alan Roe for his advice and support.

I am specially indebted to Arne Drud for his help in solving the problems that arose in running the model.

Thanks, also, to Jeffrey Round who helped me throughout my studies at Warwick.

I am grateful to Jesus Reyes Heroles and the Ministry of Finance for their interest and support.

I wish to thank Conacyt and the British Council for providing the means to study at Warwick.

Finally, my gratitude to my wife, Paulina, for her moral support, encouragement, and for her contribution to the thesis.

SUMMARY.

The objective of this thesis is to analyze three key aspects of the long-term relationship between energy policy and overall economic policy in Mexico: (1) energy-industrialization; (2) energy-labour force; and (3) energy-foreign debt.

The importance of the energy sectors in the general economy is evaluated from a historical perspective. Some of the most representative energy studies, both theoretical and empirical are reviewed. Also, the structure and specification of some general equilibrium (GE) models constructed for Mexico are compared within a SAM-type conceptual framework. The SAM approach is then used to formulate the one-period version of the model.

An optimizing intertemporal GE model is constructed and implemented to analyze the interdependence between the decisions of the various economic agents, and to explore the sensitivity of optimal policies with respect to such key parameters as elasticities of substitution and world oil prices. The starting point of the model is the work by Blitzer and Eckaus (1986a). However, given the different nature of the present study, five types of improvements have been introduced: (i) the objective function and the terminal constraints are formulated in a way that leads to more attractive price structures; (ii) the model contains truly price-sensitive endogenous choices; (iii) there is a greater degree of disaggregation of the accounts; (iv) the data base is more updated; and (v) a much improved software is employed for solving the model.

The following are some of the main conclusions derived from the various solutions of the model:

- Both the real and dual sides of the model capture a structural adjustment process towards expansion of non-oil tradeable producing sectors. Manufacturing exports replace oil and gas revenues and external capital inflows as the main source of foreign currency.

- Foreign exchange is the most serious constraint of the system, so that foreign debt reduction is considered as the most profitable way of allocating current income.

- This calls for a portfolio switching effect among the assets that constitute Mexico's wealth: foreign debt reduction affects investment in real capital assets, which, in turn, means that the economy grows below the labour force growth. Moreover, in the majority of the experiments, oil and gas extraction levels are constrained by the ceilings imposed by the government.

- Skilled labour force shortages also restrict the economy significantly. Yet, the economy is not constrained in its ability to absorb oil revenues.

INTRODUCTION.

Mexico currently faces the most serious economic and financial crisis in its modern history. The relative abundance of its hydrocarbon resources, particularly petroleum, is expected to play a predominant role in overcoming this crisis. However, the nonrenewable nature of these resources means that they must be used as judiciously as possible in the nation's best interest. The big challenge that now confronts Mexico arises from the need to gradually shift the structure of growth from its dependence on oil and gas revenues and external capital inflows, to a growth path which derives from the expansion of the domestic non-oil economy, accompanied by growth of productive domestic employment.

While the solution of the current problems is evidently most urgent, at the same time there is now a real need to evaluate long-term development strategies. In this respect, energy policy planning must have a long-term perspective to consider the structural changes desired for the economy as a whole. Also, the energy sector should be properly integrated with the rest of the economy. The purpose of this dissertation is to build an analytical framework that could help to assess three key aspects of the long-term interaction between energy policy and overall economic policy: (1) energy-industrialization because the formulation of energy policy in Mexico takes place in the context of a relatively well developed industrial structure; (2)

energy-labour force since there is a large working force which is rapidly expanding; and (3) energy-foreign debt because of the country's extremely difficult external debt situation.

The energy sector constitutes a crucial element in determining aggregate growth and its sectorial composition, not only because of its increasing share in production of industrial inputs, but also because of the repercussions it sets off in the rest of the economy with its acquisitions programme and its stimulation of new activities. In addition, the Mexican economy still is highly dependent on oil to generate foreign exchange and tax revenues despite the recent collapse in oil prices.

On the other hand, overall economic growth and the protective industrial strategy implemented in the past have represented the principal factors determining domestic energy demand in Mexico. Ever since the nationalization of the Mexican oil industry, the principal objective of the energy policy has been the satisfaction of the needs of the domestic market, and priority has been given to supplying the manufacturing industry, transport and other kinds of physical infrastructure with oil at subsidized prices. The economic influences then, flow back and forth between the energy sector and the remainder of the economy. An implication of this fact is that it is necessary to have analytical tools which can take these interactions fully into account. The tools must, therefore, be general rather than partial equilibrium models.

In addition, some of the most important issues in energy policy involve intertemporal questions such as the rate at which hydrocarbon resources are depleted, and the size, composition and financing of its investment effort. Moreover, the energy-economy aspects that this work attempts to look at imply dynamic trade-offs, for example, between accelerated or dampened growth in consumption and savings, and more or less foreign borrowing. Likewise, as many of the adjustments to changes in energy policy occur with quite long lags, the analytical framework should be able to deal explicitly with alternative time sequences and make at least medium-term projections.

These are the considerations which led to the construction and application of a multisectoral, intertemporal optimizing model as the basis for this study. The currently available energy models for the Mexican economy either isolate the energy sectors from the rest of the economy [1], or they employ static or recursive frameworks [2]. An exception to this is the work by Blitzer and Eckaus (1986a) which, as shall be explained later, represents the starting point of the present model. However, given the different nature of the

---

[1] A review of the literature concerning prediction models of the Mexican energy sector can be found in Wilards (1976). Although new models have been constructed since, the general methodologies are similar.

[2] Some of these Computable General Equilibrium Models are reviewed in section 4.1.

hypothesis and experiments of the present research, five types of modifications have been introduced. Briefly, these are the following: (i) the way in which the objective function and the terminal constraints are formulated is different; (ii) several improvements in the specification of behavioural and technical constraints are incorporated; (iii) there is a greater degree of disaggregation of the accounts, particularly regarding labour categories and energy and non-energy production activities and commodities; (iv) the data base is more updated; and (v) a much improved software is employed for solving the model.

The optimizing intertemporal general equilibrium (GE) model constructed here focuses on some of the most important aspects of the relationship between energy policy (investment, production, depletion, exports, domestic consumption, etc.) and overall economic policy that Mexico faces over the next two decades. The substantive issues considered here include among others the following:

First, what is the impact of different oil prices, production and exports scenarios, on the performance of the two main components of manufacturing exports: capital and the rest of manufacturing goods?

Second, what are the effects of alternative domestic energy consumption patterns on the amount of crude oil which is left for exports, as well as on aggregate consumption, the GDP growth rate and its sectorial composition?

Third, given that skilled labour is relatively scarce in Mexico, how restricted is the economy on its ability to absorb oil revenues and in terms of GDP and sectorial growth, and the allocation of investment?

Fourth, is the fixing of crude export ceilings imposed by the government compatible with the country's needs for foreign exchange in order to meet, simultaneously, principal and interest payments as well as imports and some other domestic expenditures indispensable for the recovery of economic growth?

Fifth, given the currently depressed oil market and a reduction in external financing, is Mexico's present full external debt service policy compatible with economic growth rates above, for example, the labour force growth?

The intertemporal structure of the model will also allow to evaluate a series of fundamental questions. For instance, in what assets should Mexico save and invest? The country's total wealth can be decomposed into three types of assets: (a) real capital assets; (b) oil and gas reserves; and (c) financial claims on the rest of the world. Therefore, a crucial dynamic issue to be addressed in this work is: how much of current income should go to accumulation of foreign assets? Similarly, how much of savings should be allocated to investment, and in which sectors? The answers to these questions are extremely difficult because they depend on several factors such as the rate of return of investment, the consumption requirements that must be satisfied, and on the terms on which domestic resources can be complemented by foreign capital. Trying to determine the optimal composition of investment also represents a complex issue. Should the emphasis be, say, on social infrastructure, or do export producing and import competing commodity sectors deserve top priority? Though there may never be ideal answers to such questions, it is hoped that the model presented here can bring out some of the essential features of the strategic choices that must be made.

As indicated previously, adequate long-term planning is essential if prudent use is to be made of the energy sector in stimulating the nation's economic development. In determining probable trends in the energy sector, and the impact of these on the rest of the economy and viceversa, an economy-wide model can be extremely helpful in evaluating both overall economic behaviour and the relationship among different branches of activity. While this thesis will discuss "optimal" growth rates, the primary objective of the research is to analyze the interdependence between the decisions of the various economic agents, and to test the sensitivity of optimal policy rules to key parameters such as the price of oil and the interest rate on foreign debt. It should also be emphasized that the model is normative in nature so that the solutions cannot be taken as forecasts.

Another main objective of this work is to provide insights into the price structure that should accompany an optimal strategy. The shadow prices derived from the dual solution of an optimizing model can become useful inputs into more detailed sectorial estimates of shadow prices, by providing the link between long-run optimal growth considerations and more partial sector studies. In particular an examination will be made of the behaviour of two macroeconomic prices: the real exchange rate and the real wage. These relative prices may vary over time and their time path is, of course, important not only for the analysis of trade and current account movements, but also for investment and project appraisal procedures.

This dissertation is composed of eight chapters. Chapter I describes the Mexican economic development as the result of the interaction between energy policy and overall economic policy from a historical perspective. A brief excursion into the history of Mexican oil and its role in Mexican economic development since the beginning of this century is in order for the purpose of understanding the formulation of energy policies in the 1970s and 1980s, and their probable adjustments to the international and domestic conditions of the future.

In the light of the historical analysis, chapter II discusses the key long-term development problems that Mexico faces as a country with oil. For the purpose of discussion, this chapter separates the interactions between energy-industrialization; energy-labour force; and energy-foreign debt, and highlights the main questions to be addressed in this study.

Chapter III reviews some of the most representative energy studies, both theoretical and quantitative, carried out before and after the oil shock of 1973-74. This chapter also evaluates, briefly, the pros and cons of the basic economy-wide approaches adopted by the quantitative studies.

Chapter IV serves two objectives. The first is to compare the structure and specification of some GE models constructed for Mexico within a Social Accounting Matrix (SAM)-type conceptual framework. The comparison is made in terms of the classification of accounts, the behavioural assumptions and characteristics, the data base and the closure rules. The second objective of the chapter is to formulate the one-period version of the model using the same SAM approach. The model is based on the SAM analytical framework, because by doing so, it is possible to choose the classification of accounts appropriate to address the issues of relevance here; it allows to check if the model is complete and it helps to understand its behaviour.

Chapter V describes the intertemporal optimizing GE model that will support the analysis of the following chapters, and whose equations complement the behavioural rules featured in the SAM of the previous chapter. Special attention is given to the objective function of the model as well as to the way in which the terminal conditions problem is handled. This chapter also examines the software package employed in the solution of the model.

The major macroeconomic features, sectorial output patterns and the shadow prices associated with each constraint of the Base Run of the model, are reported in chapter VI. The Base Run represents the reference case against which alternative policy experiments can be compared, and it is based on assumptions that represent a rough extrapolation of recent conditions of the Mexican economy.

Chapter VII explores the sensitivity of optimal policies with respect to crucial variables as world oil prices, real interest rates, rate of time preference, elasticities of substitution, and so forth. Thus, several experiments reflecting various domestic and international conditions are carried out, with the purpose of gaining some insights about the energy-economy interactions described above.

The final chapter sums up the results of this study, presents conclusions, and suggests ways in which this research could be carried further.

CHAPTER I.

ENERGY AND THE ECONOMY IN MEXICO:
A HISTORICAL PERSPECTIVE [1].

This chapter looks at the Mexican economic development as the result of the interaction between energy policy and overall economic policy from a historical perspective. The chapter is composed of four sections. Section 1.1 briefly describes Mexico's early oil history from the beginning of this century until the creation of Pemex in 1940. Section 1.2 outlines Mexico's macroeconomic background during the 1945-1976 period. Section 1.3 discusses the short-lived petroleum boom of 1977-1981. Finally, section 1.4 reviews the recent economic policies from the debt crisis of 1982 onwards.

1.1 Mexico's Oil History, 1900-1940.

Oil has been produced in Mexico since the beginning of this century. A brief description of the situation of the oil industry during those early years is, therefore, necessary in order to understand the formulation of Mexican oil policies in the 1970s and 1980s.

During the 1920s Mexico was the second largest producer in the world after the U.S. with a maximum oil and gas production of 0.53 millions of barrels per day (mb/d) achieved in 1921 (Corredor, 1981), a level of production not reached again until 1974. Between 1920 and 1925, oil

[1] General references are: Silva-Herzog (1944), Vernon (1963), Solis and Brothers (1966), Ortiz Mena (1970), Solis (1981), Cardenas (1982), Cardoso and Levy (1987), and Wionczek (1987).

represented about 40 percent of total exports (Bucay and Perez-Motta, 1987). On the other hand, however, profits from Mexican oil were until 1938, fully controlled by U.S., British and Dutch private interests. As Wionczek (1987) points out, Mexican oil exports contributed substantially to the allied victory in the First World War. Moreover, the profits from Mexican oil helped to finance the rapid expansion of the oil industry in the Middle East and South America in the aftermath of World War I.

When President Cardenas nationalized the oil industry in March 1938, declaring that hydrocarbons were to be developed by Mexicans and for Mexico, the reconstruction of the oil industry also started. This was so because foreign oil companies left oil reserves depleted, the equipment was in a state of abandonment, and Mexican management and technical personnel was almost non-existent (Silva-Herzog, 1944). In addition, all major industrial countries blockaded Mexican oil exports and organized world-wide propaganda against 'Mexican bandits' (Wionczek, op.cit.). Fortunately for Mexico, the outbreak of the Second World War saved the country from a major political and economic disaster.

These events defined to a great extent Mexico's oil policy during the post-expropriation period. In particular, there was a widespread conviction among Mexicans that oil was scarce. In 1938 crude oil reserves amounted to 814.1 millions of barrels (mb) which, with an annual production of 38.8 mb, meant that Mexico would run out of crude oil reserves in 21 years as can be seen next.

Table 1.1
Production and Reserves of Crude Oil
and Natural Gas, 1938-1987.
(Millions of Barrels)

	Total Hydrocarbons [1]			Crude Oil			Natural Gas		
Year [2]	Res (1)	Prod (2)	Years (1/2)	Res (3)	Prod (4)	Years (3/4)	Res (5)	Prod (6)	Years (5/6)
1938	1240	44	28	814	39	21	426	5	88
1948	1367	67	20	980	60	16	387	7	54
1958	4070	153	27	2512	101	25	1558	53	30
1970	5568	311	18	3288	178	19	2279	133	17
1973	5432	336	16	3270	192	17	2162	135	15
1976	11161	500	22	7279	327	22	3882	154	25
1980	60126	1039	58	47224	779	61	12902	260	50
1984	71750	1306	55	56410	1017	55	15340	289	53
1987	71750	1157	62	56410	913	62	15340	244	63

[1] Includes crude oil, natural gas liquids and condensed.
[2] Figures correspond to 31st December of each year.
Source: Pemex (1980 pp. 120-22, and 1985 p.51). The figures for 1987 were obtained from SHCP, 1988.

Mexico had been at one point highly dependent on oil and also had suffered the blockade of its oil in foreign markets. These factors made it most advisable for the country to avoid becoming "oil addicted". Consequently, from 1938 onwards, Mexico adopted an industrialization strategy (through import substitution), which considered the availability of cheap energy as one of its cornerstones. Thus, priority was given to supplying the manufacturing industry, transport and other kinds of physical infrastructure with oil at subsidized prices. Not surprisingly, the demand for hydrocarbons grew during the post-nationalization decades at an average of 10 percent per year (Wionczek, op.cit).

In 1938, the participation of the oil industry in terms of the revenues obtained through taxes and exports was very limited. Table 1.2 below shows the share of oil related taxes in the total taxes raised by the public sector for the 1938-1987 period.

Table 1.2
Share of Oil-related Taxes in Total Taxes Raised by the Public Sector, 1938-1987.
(Billions of Pesos)

Year	Total Taxes (1)	Oil Taxes (2)	Share (2/1)
1938	0.4	0.02	5.1
1948	1.9	0.1	7.7
1958	8.5	0.5	6.1
1970	36.6	1.6	4.4
1973	62.5	2.1	3.4
1976	154.8	14.5	9.3
1980	653.4	161.4	24.7
1983	2972.4	1306.5	44.0
1987	32576.7	14276.2	43.8

Source: As for Table 1.1, pp. 51 and 24, respectively.

In the nationalization year, only 5.1 percent of the public sector's revenues were obtained through oil-related taxes, while 13.4 percent of the country's exports were accounted for by oil and gas exports as shown in Table 1.3.

Table 1.3
Share of Oil Industry in Total Exports, 1938-1987.
(Billions of Pesos)

Year	Total Exports (1)	Oil Industry Exports (2)	Oil Industry Share (2/1)	Petroleum Prod. Exports (3)	Petroleum Prod. Share (3/1)	Petrochem. Exports (4)	Petrochem. Share (4/1)
1938	0.8	0.1	13.4	0.1	13.4	-	-
1948	2.7	0.4	15.0	0.4	15.0	-	-
1958	8.8	0.3	3.6	0.3	3.6	-	-
1970	17.2	0.5	2.9	0.4	2.7	0.1	0.2
1973	25.9	0.5	1.7	0.4	1.5	0.1	0.2
1976	51.9	8.0	15.4	8.0	15.4	0.0	-
1980	430.4	297.0	69.0	294.4	68.4	2.9	0.6
1984	4634.2	3172.4	75.5	1297.6	75.0	14.9	0.6
1987	28378.6	11810.6	41.6	10733.5	38.0	1037.1	3.7

Source: As for Table 1.1, pp. 25 and 18, respectively.

In 1940, the government-owned oil monopoly Petroleos Mexicanos (Pemex) was created as part of the reconstruction programme of the oil industry. As can be seen on Table 1.4, in 1939 the share of the oil industry in total public investment was only 10.3 percent. Pemex, therefore, had the difficult task of allocating the scarce financial resources between exploration, crude production, refinery construction, building of distribution networks and, after 1960, the establishment of the primary petrochemical industry.

Table 1.4
Share of Oil Industry in Total Public Investment, 1939-1984.
(Billions of Pesos)

Year	Public Invest. (1)	Indus.S. Invest. (2)	Oil Industry Invest. (3)	(3/1)	(3/2)
1939	0.2	0.027	0.024	10.3	88.9
1948	1.5	0.3	0.2	10.9	60.2
1958	6.2	2.1	1.3	21.4	63.5
1970	29.2	11.1	5.4	18.6	49.0
1973	49.8	16.2	7.7	15.5	47.5
1976	108.6	50.0	21.2	19.5	42.4
1980	478.6	221.7	128.2	26.8	57.8
1984	2082.6	961.1	594.6	28.6	61.9

Source: As for Table 1.1, pp. 49 and 23, resp.

Furthermore, the expansion of Petroleos Mexicanos during the 1940s was to be achieved without outside assistance, as explained by a joint World Bank and Mexican government study in 1952 (Mena et al., 1953).

1.2 Macroeconomic Background, 1945-1976.

The period following World War II marks the beginning of Mexico's modern economic history. Before the war, however, certain institutions emerged which were to play prominent roles in the post-1940 phase of economic development. In 1925 the Banco de Mexico was organized as the country's Central Bank and, in 1934, Nacional Financiera was founded as Mexico's official industrial development bank. Perhaps more importantly, it was not until Cardenas' presidency (1934-40) that political stability was achieved in the country [2]. Nevertheless, it was at the end of the war and at the beginning of

[2] See, for example, Hansen (1971).

Aleman's administration (1947-52), that both the private and public sectors reached the formal and informal agreements which in turn encouraged accelerated rates of savings, investment and economic growth in the years following.

From 1945 to 1976, the Mexican economy grew on average at an annual rate of 6.3 percent. On a per capita basis, the rate exceeded 3 percent. Table 1.5 summarizes the behaviour of GDP growth, inflation, real wages and the exchange rate from 1947 to 1987. This period is broken up into the six years intervals of the presidential political cycle [3].

Table 1.5
Output, Prices, Real Wages and Exchange Rate in Mexico, 1947-1987

Period	President	Real Avg. GDP %	Perc. change during period		Exchange Rate (pesos/US$)		Avg CPI
			GDP pc	Wage[1]	Start	End	
1947-52	Aleman	5.8	3.1	3.8	4.9	8.7	9.6
1953-58	Ruiz C.	6.5	3.5	0.5	8.7	12.5	6.7
1959-64	Lopez M.	6.7	3.3	11.1	12.5	12.5	2.2
1965-70	Diaz O.	6.8	3.4	4.0	12.5	12.5	3.6
1971-76	LEA	6.2	2.7	2.3	12.5	19.9	12.9
1977-82	Lopez P.	6.1	3.1	-3.3	19.9	96.5[2]	29.7
1983-88	Madrid	-0.3	-2.6	-8.3	96.5[2]	2199[2]	90.2

[1] Real Minimum Wage.
[2] From 1982 onwards Mexico switched to a dual exchange rate: a) controlled for most current account operations pegged by the Bank of Mexico; and b) the free exchange rate. This Table reports only the latter.
Sources: Cardoso and Levy (1987, p.471) and Banxico (1988).

[3] Koehler (1968) shows the coincidence of political and business cycles in Mexico. Typically, the president in turn increases government spending in the last year of the sexenio in order to complete public investment programmes. This requires corrective policies in the beginning of the new administration.

Table 1.5 shows the impressive performance of the Mexican economy in terms of real GDP growth, low inflation rates, real minimum wages growth, and exchange rate stability achieved during most of the 1947-76 period. However, inequality in income distribution did not improve [4].

This period can be divided into three different stages. The first runs from 1945 to 1954 and is characterized by erratic growth rates, currency devaluations and price instability. The second stage, from 1955 through 1970, corresponds to the "Stabilizing Development" period, also known as the "Mexican Miracle" because Mexico achieved consistently high rates of economic growth combined with low rates of inflation and a stable exchange rate. This period, however, was later criticized for worsening the income distribution, for its anti-export bias and price distortions that favoured the use of capital in place of abundant labour. The third stage corresponds, basically, to the Echeverria's administration (1971-76). This period, sometimes misguidingly referred as "Shared Development", envisioned the public sector as the engine of growth. It also marks the beginning of annual inflation rates of more than two digits, which ever since have become a feature of the Mexican economy. This period ends with a negative growth in per capita income. These stages will be examined in more detail.

---

[4] Navarrete (1970), Solis (1970), and Bergsman (1980) are major references under this subject.

1945-1954:

During the ten years that followed World War II there was neither steady growth nor price stability in Mexico [5]. Moreover, this period experienced several currency devaluations [6]. According to Ortiz Mena (1970), who was one of those responsible for the "Stabilizing Development" period, the main feature of the 1945-1954 period was the vicious circle created by the devaluations and the consequent increases in prices. The government incurred substantial budgetary deficits which were partially financed by the deposit banks, and which in turn were directly monetized. At the same time, ambitious investment programmes in excess of savings induced growth, current account deficits, and added to the upward pressure of demand on prices. Persistent deficits in the balance of payments developed as the demand for Mexican exports declined due to high domestic inflation and the deteriorating terms of trade [7]. Devaluations, then, were necessary to correct overvaluation and the deficits in external accounts created more inflation and the need for other devaluations. On the other hand, due to the

---

[5] The GDP growth, for example, went from 0.4 percent in 1953 to 10.5 percent the year after. In a similar fashion, the consumer price index rate of growth went from 14.1 percent in 1952 to -0.9 percent in 1953.

[6] The last devaluation of this period occurred in April 1954 when the exchange rate went from 8.65 to 12.50 pesos per dollar (see Table 1.5), a level maintained until September 1976. Solis and Brothers (1966) attribute the 1954 devaluation to Mexico's deteriorating terms of trade, its consequent inability to maintain an adequate level of foreign exchange reserves, and to the expansion of the money supply.

[7] The annual index of export prices to import prices (1950=100) dropped from 112.2 in 1948 to 96.3 in 1954 (Solis and Brothers, 1966).

deficits in external accounts, during the 1950s Mexico steadily received external resource transfers [8].

With respect to the oil sector, during the 1940s and early 1950s Nacional Financiera directed most of its long-term financing to basic import substitution industries, including oil. Large portions of the public investment were channelled into electrical power and petroleum fields. The share of oil industry investment in total public investment rose from 10.9 percent in 1948 to 21.4 percent ten years later (see Table 1.4). The result of this investment was annual growth rates of 10 percent for installed electrical power capacity and 6.6 percent for gas and oil production during the 1940s and mid-1950s (Hansen, 1961).

By 1948 the output of both crude and refined oil exceeded that of the nationalization year (1938) by close to 55 percent (see Table 1.1). Not only were the needs of the domestic market (growing by 9.1 percent annually) fully satisfied, but the oil industry was able to increase its crude exports. In 1948 oil exports represented 15 percent of total exports (see Table 1.3), and oil and gas taxes accounted for 7.7 percent of total taxes raised by the public sector (see Table 1.2). These revenues helped the government to finance capital goods imports and to pay back a large part of the debt finally negotiated with the oil companies.

---

[8] Marconi (1967), reviewing Mexican external resources concludes that in the 1950s external long-term capital inflows averaged $100 million, rising to $300 million in 1963 and rapidly increasing from there.

Stabilizing Development, 1955-1970 [9]:

Given the erratic growth rates, price instability, currency devaluations, and the consequent loss of confidence in the government policies of the past ten years, a change in economic strategy was called for in the middle of the Ruiz Cortines administration (1953-58). The authorities argued that a small open economy like Mexico, having the largest financial market as a neighbour, could only compete successfully with a fixed exchange rate and price stability. Consequently, the main features of the Stabilizing Development programme were the following [10]:

a) A fixed nominal exchange rate: 12.50 pesos per dollar.

b) A stable ratio of the public external debt to GDP. External borrowing was seen as a mechanism to help support the fixed exchange rate. U.S. bank claims on Mexico were $400 million in 1958 and had risen to $1 billion by 1964. External debt service increased between 1957 and 1964 from $100 to $450 billion (Marconi, 1967).

c) A low ratio of government budget deficits to GDP.

d) Promotion of import substitution through tariffs and selective licensing. Also, subsidies and tax exemptions for reinvested profits were adopted.

e) Positive real interest rates net of taxes were given to savers during the entire period. Likewise, taxation measured as a percentage of taxes plus inflation with respect to nominal interest rate was below the maximum marginal personal income tax for most of the period (Gil Diaz, 1985).

f) Reserve requirements of financial intermediaries set by the Bank of Mexico were used not only as an instrument of monetary policy but also as a technique to absorb government paper and thus provide compulsory loans to the government. They were also a way of allocating credit between the public and private sectors.

---

[9] For an overview of the macroeconomic policies followed during this period see Ortiz Mena (1970) and Gil Diaz (1983).

[10] This part is based on Cardoso and Levy, (op.cit.).

The result of this programme in terms of growth and inflation was impressive. From 1955 to 1970, real GDP grew at an average 6.7 percent per year, while the annual inflation rate was below 4 percent. At the same time, the share of investment in output increased from 14.3 percent in 1955 to 22.7 percent in 1970 (Cardoso and Levy, 1987).

The trends in the structure of production were also those normally associated with economic development (Chenery and Syrquin, 1975). Industrial output grew rapidly over this period, so that the share of industry in GDP increased from 29 percent in 1960 to 34 percent in 1970, while the share of agriculture fell from 16 percent to 12 percent in the same period.

Despite their success throughout the 1960s, the policies pursued were storing trouble for the future: firstly, income distribution among households in Mexico deteriorated during this period (Navarrete, 1970).

Secondly, the economy was moved further and further away from free trade since protection played a key role in the promotion of the import substitution policy. Also, substitution of consumer goods rather than intermediate and capital goods was favoured. Above all, concentration on import substitution meant that the export sector was relatively neglected. Consequently, from 1963 there was an upward trend in the balance of payments deficit.

The drop in agricultural output turned the country into a net importer of agricultural products in the early

1970s and, because of the anti-export bias of the regime, non-traditional exports also fell. The exports of the oil sector were not the exception. The share of oil and gas exports in the total decreased from 15 percent in 1948 to 3.6 percent in 1958 and then to 2.9 percent in 1970 (see Table 1.3). The fall of oil and gas exports was largely due to the underinvestment experienced by the sector during the 1960s which soon led to domestic energy shortages in the early 1970s.

Thirdly, the process of rural-urban migration was exacerbated as a consequence of two factors, these were: lower incomes in the agricultural sector due to price controls on basic agricultural products, and the increase in the rate of growth of population [11]. Migration in turn created poverty belts around the big cities and increased illegal immigration into the U.S. Thus, despite the fact that the economy grew at high rates throughout the period, this was not good enough to absorb the growing labour force [12].

Fourthly, during the 1960s and 1970s public sector investment was largely directed towards industry and against agriculture and energy sectors. The share of oil industry investment with respect to total public investment fell from 21.4 percent in 1958 to 15.5 percent in 1973. Likewise, compared with the investment

---

[11] Between 1940 and 1960 the share of the urban population doubled and today more than 60 percent of Mexicans live in cities.

[12] Solis (1980) estimated that GDP had to grow at 7.5 percent per year in order to accommodate the growing labour force with the existing output mix and ruling factor prices.

undertaken by the industrial sector, the share of the oil industry went from 63.5 percent to 47.5 percent in the same period (see Table 1.4). Thus, in spite of the fact that the availability of energy continued to be considered one of the cornerstones of Mexico's industrialization strategy, no long-term exploration programme was elaborated by Pemex during the 1960s (Wionczek, op.cit).

As a result of the oil industry's underinvestment, the growing energy needs of the domestic market due to the increase in output, and the fact that almost no new oil and gas reserves were discovered during this period, by 1973 Mexico had hydrocarbons reserves for only 16 years (see Table 1.1). The decline of the oil industry was also reflected in less revenues for the government in terms of oil-related taxes. The share of these taxes in the total dropped from 7.7 percent in 1948 to 3.4 percent in 1973.

Worse still, as Wionczek (op.cit.) concludes, oil policy became a sequence of partial decisions aimed at solving the industry's short-term problems. That is, instead of being incorporated into the broader context of economic development strategy, the formulation of oil policy was left to the technical experts of Pemex whose autonomy made any coordinated energy policy action increasingly difficult. At the same time, the government continued subsidizing the economy through low energy prices. Consequently, shortages started developing in exploration, production, processing and distribution of fuels.

Shared development, 1971-1976:

During Echeverria's presidential period, the public sector became the leading economic force in contrast with the policy of the former regime where the private sector's investment had been subsidized. Regulations concerning foreign private investment were changed: a minimum of 51 percent of national equity participation was required in all foreign ventures. Moreover, very large public sector investment programmes in industry, agriculture and transport were carried out [13]. Government spending kept the economy growing on average at a rate of more than 6 percent per year.

Shared Development, however, also perpetuated two fundamental flaws of the preceding period: the sluggishness of agricultural growth and the lack of foreign competitiveness of the industrial sector. The rates of growth of agricultural output averaged a negative 0.5 percent between 1971 and 1976, while the share of manufactured exports in the total fell from 27 percent in 1970 to 21 percent in 1976.

Government, therefore, failed to halt the deteriorating trend in the external sector which in turn was aggravated by a number of other factors: firstly, adverse movements of international prices for some raw materials and

[13] The share of public investment in total investment increased from 37 percent in 1970 to 44 percent in 1975 (Cardoso and Levy, op.cit.).

intermediate goods imports such as agricultural and petroleum products (Mexico became a net importer of hydrocarbons from 1971 to 1974). At the same time, the international price of several export goods and services declined as a result of a reduction in demand by major industrial countries which faced a world recession following the first oil shock of 1973-74.

Further, the past government's infrastructure investment programme led to increasing imports of capital and intermediate goods which represented about 80 percent of total imports. All these factors contributed to an upward trend in the trade deficit. The current account deficit relative to GDP increased from about 3 percent in 1971 to almost 6 percent in 1975 (Looney, 1978).

Secondly, for political reasons, a tax reform that was supposed to take place in 1972 was not carried out and the government deficit, which was about 1 percent in 1970-71, increased to 10 percent of GDP by 1976 [14]. The deficit was in part financed by an expansionary money supply which added to domestic inflationary pressures: the inflation rate rose from about 5 percent in 1970-72 to about 20 percent in 1974-75. With the consequent negative real interest rates, the ratio of financial assets to GDP started to decline. Therefore, the public sector had to obtain additional resources from abroad. The public sector's external debt more than trebled in

---

[14] According to Cardoso and Levy (op.cit.), the critical desestabilizing decision of the Echeverria's administration was to expand to correct inequality, while at the same time keeping an inadequate tax structure.

1971-76: it went from $6.7 to $20.8 billion. The cost of international borrowing also began to increase steadily: the nominal implicit interest rate on foreign debt went from an annual average of 4.64 percent in 1970 to 6.57 percent in 1975 (Serra-Puche and Ortiz, 1986).

Thirdly, domestic fuel shortages, accompanied by a rapid growth of crude and petroleum products imports, made themselves felt ahead of the first international oil shock of 1973-74. These shortages are shown by Tables 1.6, 1.7, 1.8 and 1.9 which present Mexico's production, trade and apparent consumption of crude oil, natural gas, refining products and basic petrochemicals, respectively, for selected years during 1970-1989.

Table 1.6
Production, Trade and Apparent Consumption of Crude Oil *, 1970-1989.
(Thousands of barrels per day)

Year	Prod'n	Imports	Exports	Apparent Consump'n
1970	486.6	-	-	486.6
1973	524.7	64.7	-	654.0
1976	894.3	-	94.3	800.0
1980	2129.5	-	827.8	1301.7
1984	3055.6	-	1520.4	1535.2
1989	2516.0	-	1293.0	1223.0

* Includes crude, natural gas liquids and condensed
Sources: Corredor (1981, p.1312), and Pemex (1989).

Table 1.7
Production, Trade and Apparent Consumption of Natural Gas, 1970-1989.
(Millions of cubic feet per day)

Year	Prod'n	Imports	Exports	Apparent Consump'n
1970	1822.5	48.8	106.3	1764.9
1973	1854.0	42.2	5.5	1890.7
1976	2108.7	17.2	-	2125.9
1980	3547.6	-	280.8	3266.8
1984	3752.2	5.1	147.6	3604.6
1989	3574.2	n.a.	-	3574.2

Sources: Corredor (1981, p.1313), and Pemex (1989).

Table 1.8
Production, Trade and Apparent Consumption of Refining Products *, 1970-1989.
(Millions of barrels per year)

Year	Prod'n	Imports	Exports	Apparent Consump'n
1970	167.3	17.3	22.4	162.7
1973	196.6	33.2	8.7	221.1
1976	258.4	15.7	1.2	272.9
1980	402.3	5.4	17.1	390.6
1984	464.3	12.1	40.8	435.5
1989	521.7	41.6	38.4	524.9

* Includes liquid gas, petrol, diesel, and others.
Sources: Corredor (1981, p.1313), and Pemex (1989).

Table 1.9
Production, Trade and Apparent Consumption of Basic Petrochemicals, 1970-1989.
(Millions of cubic feet per day)

Year	Prod'n	Imports [1]	Exports	Apparent Consump'n
1970	1931.1	189.0	66.0	2054.1
1973	2649.8	228.8	34.6	2843.9
1976	3946.3	329.0	1.7	4273.5
1980	7224.0	762.1	755.2	7230.9
1984	10943.4	869.3	576.1	11236.6
1989	n.a.	n.a.	n.a.	n.a.

[1] Includes those imports carried out by Pemex and directly by the consumers.
Sources: Corredor (1981, p.1314), and Pemex (1989).

The fact that by the early 1970s Mexico had lost its energy self-sufficiency which in turn had put domestic industrial development in great peril, forced Echeverria's administration first, and particularly Lopez Portillo's government, to increase considerably financial and technological resources in the search for 'new' oil in the country. The participation of the oil sector in public investment increased from an annual average of 18.1 percent in real terms during 1971-76 to almost 28 percent between 1977-80 (see Table 1.4).

Fortunately, when the short-lived, albeit serious, political and financial crisis of 1976 occurred [15], Mexico had not only regained its energy self-sufficiency, but had the capacity to start exporting crude oil at short notice and in growing quantities to take care of its extremely weak external position [16]. The share of oil exports in total merchandise exports jumped from 1.7 percent in 1973 to 15.4 percent only three years later (see Table 1.3). Similarly, the share of oil-related taxes in the total, increased from 3.4 percent to 9.3 percent in the same period (see Table 1.2). In terms of hydrocarbons reserves, by 1976 Mexico again had oil and gas for more than 20 years (see Table 1.1), thanks to the

---

[15] Shared Development ended with an IMF agreement and an orthodox stabilization programme that held back spending for the next two years in an attempt to lower inflation, build up reserves, and regain stability.

[16] Wionczek (op.cit.), argues that had Mexico not responded rapidly in the early 1970s to the impact of its domestic oil crisis, the country's economic growth would have been brought to a standstill by 1975 at the latest, if only for balance of payment reasons.

tremendous oil wealth 'rediscovered' in the states bordering the Gulf of Mexico.

The above mentioned figures, however, were to be increased several times over during the next few years, at a point where Mexico should again become, just as it had been between 1900 and 1930, an export-oriented economy. As it will be pointed out in the next section, this rapid passage from scarcity to over-abundance gave birth to highly exaggerated ideas about making out of hydrocarbons a centrepiece of the country's future economic development. As Bueno (1982) states, Mexico consciously or unconsciously, tended to overvalue itself as an 'oil country' and undervalued itself in other fields of economic activity. In the words of Wionczek (op.cit., p. 334): "Mexico is not an 'oil country' but a 'country with oil'.

1.3 The Oil Boom, 1977-1981.

The 'rediscovery' of Mexican oil wealth led to a spectacular growth of the oil industry during Lopez Portillo's presidency (1977-82). An examination of the following figures will show the magnitude of this phenomenon [17]:

- Proven hydrocarbon reserves, which includes crude, liquids and natural gas, climbed from 5,432 mb in 1973 to 72,000 mb in 1981.

- Crude oil and natural gas production increased from a daily average of 0.9 mb/d of oil equivalent in 1973 to about 3.3 mb/d in 1981.

---

[17] The following statistics were obtained from La Industria Petrolera en Mexico, (1980) and (1985).

- Crude oil exports grew from an average of 16,000 b/d in 1974 to 1.25 mb/d in 1981. This, coupled with the constant rising in international oil prices, meant an income from oil and gas exports of $14,573.3 million in 1981 (75 percent of total merchandise exports), compared with $70 million obtained in 1974 (4.7 percent of total merchandise exports).

- Production of refining products rose from 539,000 b/d on average in 1973 to 1.1 mb/d in 1980.

- Production of basic petrochemicals increased from 2.6 mmt in 1973 to 7.2 mmt in 1980.

- Gross fixed investment of the oil sector grew at an annual average of 20.9 percent in real terms during 1974-80.

- The share of oil related taxes in total taxes raised by the public sector jumped from 3.4 percent in 1973 to 44 percent in 1983.

Not surprisingly, given this background, the IMF programme of 1976 was abandoned since Mexico, because of the magnitude of its oil reserves in particular, no longer needed IMF resources. Moreover, by early 1979, private capital started to flow in as a result of the expectations concerning future growth [18].

As Wionczek (op.cit.) explains, the expectations created by the oil boom were grandiose indeed: oil wealth was to offer the State the economic and social management capacity previously non-existent; it was to provide the country with practically unlimited financial capacity; the petroleum industry expansion plans were to make it possible indirectly to solve the most intractable long-standing problems (e.g. low agricultural productivity, bad income distribution and dependence on the exterior); petroleum products were to permit accelerated and

[18] Zedillo (1987) estimates that during the 1976-79 period, capital flight reached $3.9 billion.

sustained economic growth (at about 8 percent a year); there was to be sharply increased investment in the key sectors considered the engine of growth; a decrease in foreign borrowing and considerable improvement in social welfare would become possible.

Behind all these over-optimistic expectations there was a very simple assumption, shared by most energy experts of that time: the allegedly limited extent of oil and gas reserves in the face of continuously growing demand for fuels both in advanced and developing countries was to guarantee in the decades to come, all producers, steady expansion in hydrocarbons exports at constantly rising prices [19].

However, even the most enthusiastic supporters of the position that Mexico should use oil as the pivot of the country's development became rapidly aware of the internal and external limitations of such position. As shall be seen in chapter II, the fact that Mexico was a semi-industrialized country offered both advantages and disadvantages in the oil boom. Also, economic and financial advantages were counter-balanced by political disadvantages arising from the country's geopolitical position: US was and still is the world's largest oil importer and its energy sector happens to be controlled fully by powerful international private interests.

---

[19] When discussing the assumptions of the National Energy Programme (1980) it shall be seen that Mexican authorities expected an increase in world oil prices between 5-7 percent per year in real terms until the year 2000.

The negative aspects of the growing presence of oil in the Mexican economy were summarized by the sceptics in eight major points (Bueno, 1981):

1) The increase in the country's overall economic dependence on the US market [20].

2) The negative changes in the structure of exports in favour of oil [21].

3) The substantial contribution of the oil sector to the internal inflationary pressures, in spite of continuing low domestic prices of petroleum products.

4) The slowdown of the modernisation and drop in efficiency of manufacturing industry, which in an 'overheated' economy was selling all its output whether of high or low quality, and whether needed or not from the development viewpoint.

5) The serious negative effect of the oil sector on the balance of payments for three reasons: first, the increasing demand for imports of the oil industry itself (reflecting domestic capital-goods industry deficiencies); second, the increasing demand for luxury consumer goods (reflecting the deterioration in income distribution partly due to the the development patterns of an economy which is excessively dependent on oil); and third, the growing demand for foreign loans reflecting the internal problems of the oil industry management.

6) The general relaxation in public expenditure discipline.

7) The negative impact of the oil industry on regional development differences.

8) The serious ecological consequences of the new oil activities along the Gulf of Mexico and in south-western parts of the country.

While all these reservations proved ex-post largely correct, the State followed the policy of continued expansion of the oil sector to accelerate the growth of the economy.

---

[20] In 1980, for example, Mexico sold 68.1 percent of its oil to the US and about 70 percent of its total exports.
[21] This so called Dutch-disease phenomenon shall be analyzed in sections 2.1 and 3.1. See also Table 1.11 further down.

The debate between sceptics and the oil boom enthusiasts was given a new lease of life with the appearance at the end of 1980 of the National Energy Programme (NEP), containing analysis of demand and supply of major primary energy sources, targets for production of hydrocarbons to 1990 and the projection of uses of all energy sources in Mexico to the year 2000 [22]. The NEP set as its major objectives (p.17):

a) Satisfaction of the national primary and secondary energy needs.

b) Rationalization of energy production and uses.

c) Diversification of the primary energy sources, in particular the non-exhaustible resources.

d) Integration of the energy sector into the general development of the economy.

e) Detailed knowledge of the country's energy resources.

f) Building up the scientific and technological infrastructure permitting the development of the country's energy potential and the application of new energy technologies.

The targets and projections of the NEP to the year 2000 were based on the following assumptions (pp. 22-30):

1) A GDP growth of 8 percent on average per year from 1980 to 1990.

2) An increase of international oil prices between 5 and 7 percent per year in real terms until the year 2000.

3) A level of crude oil exports of about 1.5 mb/d and 300 mcf/d of natural gas from 1980 and 1990. At the same time, the share of oil and gas exports in total exports should not be greater than 50 percent in any one year.

4) An upper technological limit to the production of oil and gas between 8 and 10 mb/d.

---

[22] Programa de Energia: Metas a 1990 y proyecciones al año 2000 (resumen y conclusiones). Secretaria de Patrimonio y Fomento Industrial, noviembre 1980.

The debate between sceptics and the oil boom enthusiasts was given a new lease of life with the appearance at the end of 1980 of the National Energy Programme (NEP), containing analysis of demand and supply of major primary energy sources, targets for production of hydrocarbons to 1990 and the projection of uses of all energy sources in Mexico to the year 2000 [22]. The NEP set as its major objectives (p.17):

a) Satisfaction of the national primary and secondary energy needs.

b) Rationalization of energy production and uses.

c) Diversification of the primary energy sources, in particular the non-exhaustible resources.

d) Integration of the energy sector into the general development of the economy.

e) Detailed knowledge of the country's energy resources.

f) Building up the scientific and technological infrastructure permitting the development of the country's energy potential and the application of new energy technologies.

The targets and projections of the NEP to the year 2000 were based on the following assumptions (pp. 22-30):

1) A GDP growth of 8 percent on average per year from 1980 to 1990.

2) An increase of international oil prices between 5 and 7 percent per year in real terms until the year 2000.

3) A level of crude oil exports of about 1.5 mb/d and 300 mcf/d of natural gas from 1980 and 1990. At the same time, the share of oil and gas exports in total exports should not be greater than 50 percent in any one year.

4) An upper technological limit to the production of oil and gas between 8 and 10 mb/d.

---

[22] Programa de Energia: Metas a 1990 y proyecciones al año 2000 (resumen y conclusiones). Secretaria de Patrimonio y Fomento Industrial, noviembre 1980.

5) A level of hydrocarbons reserves of 60,000 mb in the first scenario, and 100,000 mb in a second hypothesis assuming that probable reserves would become proven reserves.

6) A progressive reduction in the income elasticity of domestic energy consumption, from 1.7 observed during 1975-1979 to 1.3 in the conservative scenario and to 1.0 in the optimistic one.

7) In order to avoid excessive inflationary pressures and to continue the policy of supplying the domestic industry with oil prices below world levels, the domestic prices should get to represent 70 percent of international prices for industrial fuels, petrol and diesel, and the price gap of other petroleum products be virtually eliminated over a ten year period.

With perhaps the exception of point 5 and in some respects, item 7, the rest of the assumptions and targets had not been fulfilled by the end of 1987:

1) The GDP grew on average at about 1.9 percent per year during 1980-87, well below the 8 percent target.

2) Table 1.10 shows the declining pattern followed by world oil prices from 1980 to 1987, and in particular the collapse of the market in 1986.

Table 1.10
Movements in the World Oil Price, 1980-87.
(US$ per barrel)

Year	OPEC [1]	Rest of the World [1]	Mexico Istmo [2]	Mexico Maya [3]
1980	34.82	38.54	n.a.	n.a.
1981	34.13	34.35	35.00	26.50
1982	33.54	31.72	32.50	25.50
1983	28.59	28.65	29.00	25.00
1984	28.43	28.16	29.00	25.50
1985	27.81	26.14	26.21	21.93
1986	12.18 [4]	14.40 [5]	13.53	10.74
1987	16.88 [4]	18.73 [5]	17.46	14.89

[1] Avg. price (fob) weighted by volume of exports.
[2] Density API 330 (condensed).
[3] Density API 220 (crude).
[4] Corresponds to the avg. Arabian Light Price.
[5] Corresponds to an avg of Brent and WTI.
Sources: Bucay and P. Motta (1987, p.36), and SHCP (1987, p.36)

3) Although the level of crude oil exports, between 1980-87, was about 1.4 mb/d and around 250 mcf/d for natural gas, as expected in the NEP, the share of oil and gas exports in total exports has been in several years superior to the 50 percent target mentioned there (see Table 1.11).

Table 1.11
Exports of Oil, Primary, Extractive and Manufacturing Sectors with Respect to Total and Merchandise Exports 1976-1987

	1976	1980	1984	1987
Exports of the oil sector				
% of total exports [1]	6.8	41.8	50.5	28.2
% of merchandise exports	15.4	69.0	68.6	41.8
Exports of primary sector				
% of total exports [1]	14.2	6.1	4.4	6.9
% of merchandise exports	32.1	10.1	6.0	10.3
Exports of extractive sec				
% of total exports [1]	2.5	2.1	1.6	1.9
% of merchandise exports	5.7	3.4	2.2	2.8
Exports of manuf. sector				
% of total exports [1]	20.6	10.6	17.0	32.4
% of merchandise exports	46.7	17.5	23.1	48.0

[1] Includes all current account incomes.
Sources: Corredor (1981, p.1322) and Banco de Mexico (1988).

4) The technological limit to the production of oil and gas is today about 5-7 mb/d , below the 8-10 mb/d range expected.

5) In 1987 the level of hydrocarbons reserves was 71,750 mb, that is, a level of reserves between the two scenarios proposed by the programme.

6) The recession of the economic activity in Mexico has certainly reduced the domestic demand for energy consumption. On the other hand, there has been an increase in the internal dependence on hydrocarbons. Nowadays, hydrocarbons represent 90 percent of primary energy production. Unfortunately, there are no recent figures in respect of the income elasticity of domestic energy consumption.

7) Domestic processed hydrocarbon prices reamined unchanged throughout the oil boom. A first increase was not introduced until late 1981. Then, during the second

half of de la Madrid's government (1983-88), the domestic price of several oil derivatives has increased sharply. In 1988, for example, it is estimated that petrol and natural gas would be 87.0 and 83.9 percent of international oil prices, respectively, above the 70 percent target of the NEP. However, some other petroleum products still lag well behind world prices: diesel is expected to be 57.9 percent in 1988; and in 1986, the domestic price of heavy fuel oil was 28 percent of international prices (SHCP, 1988).

On the other hand, during the 1978-82 period, public sector investment soared and the share of investment in GDP rose to 30 percent in 1981. The investment boom was associated with a huge rise in imports, mostly of capital goods and intermediates [23]. At the same time, since fiscal policy was expansionary and monetary policy accommodating, inflation picked up after 1978.

Nevertheless, public sector prices were adjusted at a slower pace and the exchange rate crawled at a pace lower than the inflation differential between Mexico and its trade partners. The appreciating real exchange rate led to reductions in non-oil exports: faced with a domestic market expanding at 9 percent a year and an appreciating exchange rate, entrepreneurs had no incentive to sell abroad. Consequently, the total trade balance remained negative throughout this period despite the oil export boom, and Mexico continued to accumulate external debt.

Summing up, throughout the entire administration of Jose Lopez Portillo, regardless of discussions between the sceptics and the oil boom enthusiasts, oil activities were given top priority in national economic policy.

[23] Imports increased at 50 percent per year on average in that period which was largely due to the oil industry's expansion.

Above all, the whole economy became increasingly oil addicted: current account was now basically dependent on the world price of one commodity, and because taxes on oil revenues were the chief source of government revenue, the budget deficit was also chiefly determined by the behaviour of international oil prices. The unexpected reversal of the behaviour of oil prices from the second half of 1981 made the difficulties imposed by such a situation dramatically clear.

More importantly, as Cardoso and Levy (op. cit.) conclude, because of the magnitude of the oil reserves and the expectations concerning the pattern that world oil prices would follow, several imbalances of the Mexican economy such as overvaluation of the exchange rate, price distortions, and misallocation of resources were allowed to accumulate for too long. The oil discoveries eliminated any need for radical changes and thus, the government decided to postpone the correction of those imbalances. As shall be explained in the next section, the adjustment to the economic crisis of 1982 and 1986 came too late and in an extremely costly way.

1.4 Recent Policies, 1982-1988.

In 1982 Mexico faced a deep economic crisis as a consequence of internal and external disequilibria. By the end of Lopez Portillo's administration, the public sector overall deficit climbed to an unprecedented level (17.1 percent of GDP); the external sector imbalance had become unmanageable (the current account deficit was

$6,221.0 million), and the financial systems showed the effects of rapid deterioration (overall financial savings decreased by 30.5 percent in real terms; capital flight accelerated [24], the Central Bank pulled out of the foreign exchange market causing an immediate devaluation of 70 percent, the foreign commercial banks refused to rollover loans, etc). Furthermore, the growth in prices pointed towards hyperinflation (the inflation rose from an annualized rate of 63.6 percent during the first quarter of 1982 to 123.8 percent in the last) and, for the first time in decades, GDP decreased (by 0.5 percent in 1982 and then by 5.3 percent in 1983).

Despite that several short-term factors, related mainly to demand management problems, the drop in international oil prices in mid-1981 and the rise in world interest rates [25], triggered the crisis, other deficiencies of the Mexican economy, of a more structural nature, were also brought to light. The industrial plant, while basically oriented to the domestic market, relied largely on imported raw materials and other inputs. In consequence, both the public and private sectors grew increasingly dependent on oil exports to meet their foreign currency requirements. Also, when the oil price started to fall and with it oil revenues through taxes

[24] Capital flight reached at least $17 billion in 1981-82 according to estimates by Zedillo (1987). There is a considerable divergence between estimates by Morgan Guaranty (1987), Cuddigton (1987) and Zedillo (op.cit.) reported in Lessard and Williamson (1987).

[25] World interest rates increased sharply as a result of the US shift to tight monetary policy. Between 1978 and 1981 the 3 month Libor rate climbed from 8.8 to 16.8 percent. By itself this increase in interest rates, if financed by new loans, would have raised the debt by 8 percent per year (Dornbusch, 1988).

and exports, this in turn meant insufficient domestic savings to cover the country's investment needs, leading to an increasing reliance on external debt to finance economic development. Moreover, large government subsidies became an enormous burden on public finances. Finally, the inefficiency of certain public and private enterprises led to lower levels of productivity.

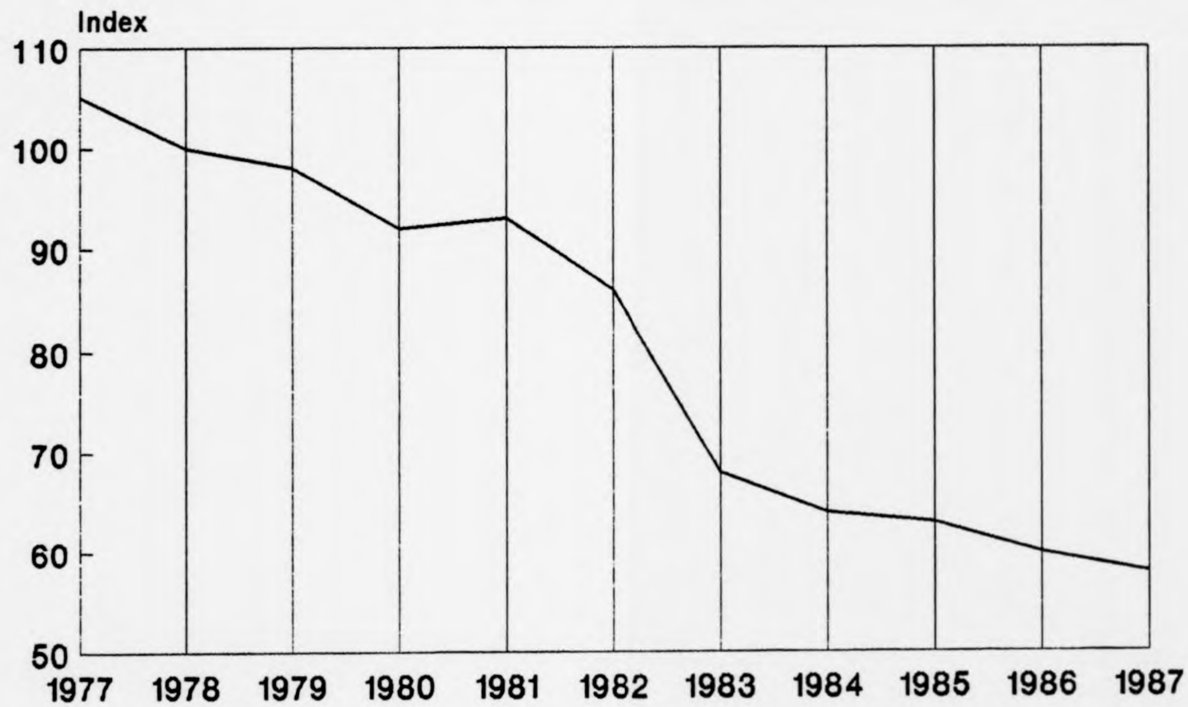
Not surprisingly then, when de la Madrid's administration took office in December 1982, it also signed an agreement for a three-year IMF stabilization programme. The starting point and evolution of this programme was characterized by the following aspects:

Real Wages:

During the 1955-70 period, real wages increased at an annual average of 6.9 percent. In the 1970s and beginning of the 1980s real wages had, in general terms, remained at the same level despite its erratic evolution. Therefore, at the start of the stabilization programme it was thought that part of the reduction in national income (a key feature of any stabilization programme) could be obtained at the expense of real wages. Thus, the programme instituted a restrictive wage policy, aimed at reducing the budget deficit, and thereby the inflation, as well as gaining external competitiveness. Real wages did fall dramatically as shown in Figure 1.1, and the working class and the population at large did suffer from the adjustment programme.

Figure 1.1

Real Minimum Wage in Mexico.
(1978=100)



Source: Cardoso and Levy, 1987.

At the same time, the unemployment situation deteriorated greatly, given the size of the urban informal sector and the absence of unemployment benefits. The 1982 crisis came at a particularly bad time because of demographic dynamics: the rate of growth of the labour force will be the highest in the second half of the 1980s, rising to up to 3.8 percent (STyPS, 1986). Just when the economy needs to grow fastest to absorb the labour force, the opposite has occurred.

Exchange rate:

Faced with the erosion of the country's reserves and in an attempt to avoid the inflationary pressures of large devaluations, a two-tier exchange rate system was adopted on August 5, 1982 (see Table 1.5 for an explanation of these two exchange rates). In September of that year, banks were nationalized and exchange controls were established for the first time since the failed attempt to impose exchange controls in 1930, and a black market developed [26]. Thus, the stabilization programme aimed at consolidating the two exchange rates that existed alongside the black market. Massive devaluations took place in 1982 and 1983 pushing up the real exchange rate. Indeed the current account of the balance of payments became largely positive ($3,631.2 million on average in 1983-85). One of the reasons for improvement in the current account was a sharp fall in imports, resulting from economic contraction. Unfortunately, the real

[26] For an analysis of the theoretical and policy aspects of dual exchange rate systems, see Lizondo (1986).

exchange rate was again allowed to decline in 1984 and 1985 and the current account started to deteriorate and became negative in 1986 ($1,270.4 million). Falling oil prices and capital outflows led once again to an exchange rate collapse in 1986 and 1987. The real exchange rate rose immediately after the oil price drop to compensate for the deterioration in the terms of trade [27], adding inflationary pressures (inflation rate went from 63.7 percent in 1985 to 105.7 percent in 1986).

Public Finances:

Fiscal adjustment was seen as the main instrument for eliminating excess demand and consequently inflation. The overall public sector deficit, measured in nominal terms, was reduced from 17.1 percent in 1982 to 8.4 percent in 1985. This reduction came mainly from a 32 percent cut in public investment and the sharp reduction in real wages and salaries in the government sector. There was also an increase in indirect taxes and an upward adjustment in public sector prices [28].

However, between 1983 and 1987, the whole improvement in the non-interest budget went to finance increased interest payments, which in part reflected the ongoing inflation since interest payments on the domestic public debt contain a large component of inflation-induced

[27] The international price of oil fell from $26.1 per barrel at the end of 1985 to $7.7 in July 1986. The major varieties of Mexican oil, Istmo and Maya, suffered price declines of 40.8 and 43.2 percent, respectively, in 1986 as seen in Table 1.10. Consequently, the terms of trade deteriorated 25 percent during that year.

[28] Additional revenues resulting from public sector price increases are estimated at 2.7 percent of GDP in 1983, and 2.1 percent in 1984 and 1985. (SHCP, 1986).

expenditures that correspond to amortization of the principal. Above all, during that period Mexico made an unprecedented net transfer of resources to its foreign creditors of more than $8 billion per year as a result of a net external flow of credit much lower than the interest payments on external debt (SHCP, 1988) [29]. This is further examined in section 2.3.

The collapse of the world oil market in 1986 severely impaired public finances and cut export earnings substantially: it is estimated that in that year the public sector lost 2.4 trillion pesos of oil revenues, and the share of oil exports in total merchandise exports fell from 78.2 percent in 1982 to 39.3 percent in 1986. Thus, the estimated loss in oil revenues was equivalent to 6 percent of GDP.

To summarize, by July 1986 the fragility of the adjustment programme became obvious: negative growth, high rates of inflation, zero net investment, capital flight, falling real wages, falling world oil prices and net transfer of resources abroad made the current restrictive policies unsustainable. As a result of this background, de la Madrid's government reached an unprecedented agreement with the IMF. The Fund accepted the concept of the deficit corrected for inflation as the best indicator for evaluating the country's fiscal policy and approved a programme that considers the foreign debt

[29] When the stabilization programme was signed, Mexico was supposed to get a positive external transfer of about $14,600 million per year for the 1982-84 period (SHCP, 1988).

as a problem to be overcome by growth rather than by recession.

Several factors explain the shift of emphasis from adjustment to growth. Among these, the most important are the following [30]:

- An economic recession has a negative effect on tax revenues, therefore, to accommodate both the decrease in tax revenues and the reduction in oil earnings, massive cuts in public sector expenditures would be required. As a consequence, the economy would inevitably move from recession to depression, Mexican industry would be undermined, and the country's capacity to service its debt eventually eroded.

- Without adequate economic growth, it will be impossible to create jobs in the numbers required.

- Further investment cuts would impede public and private enterprises from carrying out necessary capital improvements. There would also be severe effects on the functioning of the industrial plant and on economic welfare.

- In 1983 the economy was emerging from a period of high growth. Profits, salaries, wages, and employment had increased, thus providing a "reserve" on which to draw. In 1986, the harsh effects of four years of economic adjustment were evident, and the room for further adjustment had been exhausted.

The programme also includes two mechanisms of compensatory financing. The first protects the Mexican economy against erratic fluctuations in the price of oil. This mechanism is explained in the next section. The second mechanism, a growth facility, would come into effect in the event that the economy did not show signs of recovery in the first quarter of 1987.

The oil crisis, on the other hand, finally convinced the government that a more outward looking and efficient

[30] This part is based on SHCP, 1987.

industrial sector was needed. Also, because during the next few years oil earnings are projected to remain substantially lower than in the 1983-87 period, the government is trying to change the orientation of the industrial plant so that non-oil exports can rapidly become an increasingly important source of foreign currency. In 1986, therefore, a new export promotion package was introduced [31], and Mexico joined the GATT with the aim of stimulating non-oil exports.

At the same time, the government has liberalized imports by means of a reduction of the maximum import duty from 40 to 20 percent, as well as a virtual elimination of official prices. Import liberalization and export promotion then, aim to stimulate economic growth as well as improve the efficiency of the domestic industrial plant. International competition is expected to induce private and public enterprises to increase their productive efficiency, thus helping to solve a major structural problem of the Mexican economy.

Finally, Mexico has also been implementing new ways of reducing its external debt since foreign indebtedness represents one of the most important constraints on Mexico's economic development. These mechanisms are briefly explained in the following chapter.

In summary, the above sections have tried to describe how Mexican economic development has been determined by

[31] The government granted financial support and fiscal incentives to exporters and virtually eliminated export duties.

both energy policy and overall economic policy. It was seen that integration of the energy sector into the general development of the economy has not always been accomplished. Moreover, in Mexico, policy decisions are traditionally short-term because the presidential periods are of six years so that the different governments have had to find immediate solutions to problems and in general have tended to set aside the solutions to the long-term problems.

A typical example of this was the fact that oil discoveries in the late 1970s permitted Mexican authorities to postpone the correction of several structural imbalances and as a result, the structural changes of the 1980s have been very costly to implement, particularly in terms of a severe reduction in the standard of living of the majority of the population as Table 1.12 shows.

Table 1.12
Comparative Levels of Real Per Capita Income, 1955-1985.
(Index United States = 100)

	1955	1972	1980	1985
Mexico	24	28	32	28
Argentina	30	41	40	30
Brazil	15	20	27	23
Korea	12	17	25	31
Spain	31	50	52	48
United States	100	100	100	100

Source: Dornbusch (1988, p.4).

Table 1.12 uses real income data adjusted for international purchasing power comparisons. On that basis, in 1985 Mexico had less than one-third of the U.S. standard of living. The thirty percent growth in the relative standard of living, between 1955 and 1980, has since shrunk back due to the poor growth performance of the 1980s.

Nowadays, Mexico's economic crisis and the situation of the world energy market present Mexican planners with the difficult task of incorporating energy policy into the broader context of economic development strategy. Moreover, while the solution of the current problems is evidently most urgent, in particular to reduce the inflation rate [32], at the same time there is now a real need to evaluate strategies for establishing long-term development. In this respect, hydrocarbons reserves in Mexico are such that they still represent one of the main tools for the development of present and future generations. The next chapter discusses the key long-term development problems that Mexico faces as a country with oil and which represent the issues to be addressed in this study.

---

[32] Mexican inflation stabilization programme is underway since December 1987 and has succeeded in reducing the inflation rate from 15 percent per month (at the outset of the programme) to rates below 2 percent per month. The main mechanism for this inflation reduction consists of a coordinated programme of reduced exchange depreciation, price freeze on public sector goods, voluntary price restraint by the private sector, a de facto wage freeze and a radical cut in government spending. The starting point of this programme is the recognition that a large part of the high inflation is essentially inertial: today's inflation will be approximately what it was yesterday because of formal and informal indexation and economic agents' expectations.

CHAPTER II.

ENERGY - ECONOMY INTERACTIONS: THE CASE OF MEXICO.

One general conclusion that can be drawn from the historical analysis of the previous chapter is that the hydrocarbons industry has had and will continue to have a significant impact on the rest of the Mexican economy. Energy prices and production have played a crucial role in determining aggregate growth and its sectorial composition. Also, oil export earnings have helped to lighten the restrictions on both the balance of payments and the public sector's finances. On the other hand, overall economic growth and the protective industrial strategy implemented by the government have been the principal factors determining domestic energy demand in Mexico. It is this extensive interaction between energy policy and overall economic policy that it is sometimes referred as "energy-economy" interactions.

There are many aspects of energy-economy interactions that deserve attention for the case of Mexico and which have been mentioned during chapter I. There are, however, three crucial energy-economy interactions that would seem to represent the main long-term development issues for the Mexican economic context: the relationship between energy policy (investment, production, depletion, exports, and domestic energy pricing policies), on the one hand, and: 1) industrialization; 2) labour force; and 3) foreign indebtedness on the other. As already explained, the reason is that the formulation of energy policy in Mexico takes place in the context of a relatively well developed industrial structure, a large labour force which is rapidly expanding, and an extremely difficult external debt situation.

All these aspects are, of course, interconnected: the relationship between energy and industrialization, for example, will affect the allocation of the labour force throughout the economy, and the needs for foreign exchange. However, for the purpose of discussion, this chapter separates these interactions in three sections as follows: section 2.1 analyzes the main interactions between energy policy and industrialization; while sections 2.2 and 2.3 examine respectively some of the feed back effects between energy policy-labour force, and energy policy-foreign debt. Also, each section shall try to highlight some of the relevant questions that represent the issues to be considered in the following chapters.

2.1 Energy Policy - Industrialization.

The fact that oil and gas production comes from an exhaustible resource implies the need to find an optimal depletion policy, and consequently, its exhaustible nature means that hydrocarbons cannot be the basis of indefinite growth. In effect, the Mexican government faces the problem of deciding how fast to draw down the mineral resources and how to divide the mineral rents between consumption and investment. The theory of exhaustible resources [1] tells us that there are, basically, three choices about exploiting mineral deposits:

a) do not mine the asset, but let it rise in value while still in the ground,

b) mine the asset and use the proceeds for current consumption, and

c) mine the asset and purchase capital assets, real or financial.

The trade-off between these options depends upon the following factors: the absorptive capacity of the economy, the marginal return on domestic investment, the return on foreign investment, the anticipated development of the price of oil, the cost of lifting during the period considered, and the government's (and the society's) discount rate. The most vexing problem, as Lewis Jr (1984) points out, is that of the choice of the discount rate [2]. The higher the social discount rate, the quicker the resource will be used up, and the smaller the stock of income-earning assets left to the future generations.

In principle the theory also gives us a fairly clear general rule of asset choice. As Solow (1974, p.33) states, "a rational investor, calculating with efficiency prices, should be at all times indifferent at the margin between holding capital goods and holding mineral

[1] Some of the major references on this subject include: Hotelling (1931), Dasgupta and Heal (1974), Solow (1974) and Stiglitz (1974).
[2] In Solow's words (1974, p.10): "If exhaustible resources really matter, then the balance between present and future is more delicate than we are accustomed to think; and then the choice of a discount rate can be pretty important and one ought not to be too casual about it".

deposits as earning assets". In other words, Mexico should mine the asset and reinvest the proceeds in other assets, as long as the return on those new assets exceeds the expected return on holding its mineral on the ground. However, applying this principle is difficult for several reasons, for example, market prices may systematically move away from efficiency prices, and there is uncertainty about the future trend of mineral prices [3].

In practice, Mexico's depletion policy has been conservative despite the relatively high absorptive capacity of the economy (e.g. unemployment, low productivity, and external indebtedness). As was mentioned in section 2.3 the Mexican government has imposed crude production and export ceilings since the oil wealth was rediscovered. Also, because of the expected increase in international oil prices and the almost unlimited access to foreign capital markets external borrowing was considered a cheaper way of obtaining foreign exchange than oil exporting [4].

The recent developments in the world oil market have drastically modified the previous forecasts of the price and volume of Mexican petroleum exports for the years to come. During the 1988-91 period, for example, oil earnings are projected to remain substantially lower than in the 1983-85 period (SHCP, 1987). This, coupled with

---

[3] Heal (1975), in particular, points out the importance of risk aversion in leading to nonoptimally fast depletion.
[4] Before June 1982, as Zedillo (1985, p.310) states: "to the international bankers' comfort, Mexico became the 'champion of absorption' not only of its oil revenues, but of others as well".

the unprecedented net transfer of resources abroad and the consequent enormous debt service burden makes an evaluation of the official position concerning oil exploitation necessary.

One of the main objectives of this work is to build an analytical tool that could help to assess the strategy followed by the government in terms of depletion policy under several assumptions regarding, for instance, the price of oil, the cost of foreign borrowing and the social discount rate. As shall be discuss in chapter V, the model constructed for Mexico chooses endogenously, among other things, the optimal depletion pattern in a long-run horizon. Hence, the trade-offs of alternative optimal depletion solutions are reviewed and in particular, the government's decision to fix crude export ceilings is analyzed. This issue is further examined in the subsection dealing with energy and foreign debt interactions.

On the other hand, since the resources derived from production and exports of hydrocarbons are transitory and volatile, and mineral rich countries tend to have high rates of exports and imports to GDP, these countries are prone to undesired large fluctuations in national income. This means that Mexico must modify the present situation of dependency on oil and gas into a one of a self-sustaining economy in order to secure a continuity of income. This transition requires that non-oil exports should rapidly become an increasingly important source of foreign currency. The establishment of the basis of an efficient industrial plant is, therefore, required [5] because manufacturing exports are more apt to be successful in a country such as Mexico [6]. Furthermore, industrial activities constitute a dynamic force in stimulating economic growth: they not only provide necessary capital goods inputs to raise productivity and to generate employment and income in the economy, but also accelerate their own growth as well as growth in other sectors [7].

The performance of the industrial sector in Mexico in the post-war period has been generally impressive. As a consequence, Mexico is now the tenth largest country in the world in terms of GDP originating in manufacturing (Kim, 1987). As can be seen in Table 2.1, by 1980 Mexico produced more than 10 percent of the total Third World manufacturing output. The manufacturing industry accounted for nearly a quarter of GDP in 1986, and employed about 20 percent of the labour force.

---

[5] This does not imply that agriculture or any other primary-sector activity are relegated to a secondary role since a healthy expansion of the industrial sector requires a balanced growth in the primary sector and viceversa. Nonetheless, while the production in agricultural or extractive activities is generally constrained by natural resource endowments, the development of the industrial sector is less restrained by these factors.
[6] See Bhagwati and Srinivasan (1979).
[7] For a discussion of the dynamic attributes of industry in the economic growth process see Hirschman (1958).

Table 2.1
The Share of Manufacturing Value
Added in LDC *, 1980.

Country	Share
Brazil	22.66
Mexico	10.85
Argentine	9.86
India	8.27
Republic of Korea	4.46
Turkey	3.73
Iran	3.02
Venezuela	2.61
Philippines	2.51
Thailand	2.01

TOTAL	69.98

* Excludes China and other Asian socialist countries.
Source: Kim (1987, Table 1 p.208).

Yet, as stated before, the industrial plant has certain weakness which became manifest during the early 1970s and reappeared in a more acute form during the present crisis. In particular, the protective industrial strategy implemented by the government through energy price subsidies and quantitative restrictions (import licenses) has been criticized for promoting inefficiency.

Setting energy prices below its opportunity cost has been inconvenient for Mexico's development for various reasons: it has been inefficient in the neoclassical sense of efficient allocation of resources; large government subsidies became an enormous burden on public finances; it has further led to the deterioration of the structure of relative prices; and it has promoted an excessive use of hydrocarbons as a primary source of energy.

Despite the fact that experience has shown the validity of these arguments against energy price subsidies, it was not until few years ago that the government acknowledged a reduction in the subsidies as an essential step towards the improvement of public finances, enhanced efficiency in resource allocation, reduction of waste and improving the savings and conservation of energy in all sectors of the economy, and the elimination of certain inequalities in the economic system. As explained before, some progress has been achieved in this respect, though several domestic petroleum products are still below world levels.

The fact, then, that from 1938 onwards energy policy in Mexico has subsidized the manufacturing industry with cheap petroleum products has promoted an income elasticity of energy consumption greater than one. Actually Mexico has one of the largest income elasticities of energy consumption despite its mild weather (Corredor, 1981).

Therefore, one of the aspects regarding energy policy and industrialization to be considered in this work consists in analyzing the effects of different domestic energy consumption scenarios on the amount of crude oil which is left for exports, as well as on aggregate consumption, the GDP growth rate and its sectorial composition.

A second issue regarding the interaction between energy and industrialization consists in analyzing some of the aspects of the well known Dutch-disease phenomenon [8] which can be briefly explained as follows: the oil boom is an export boom whose revenues are partly spent on non-traded goods which leads to a real appreciation (i.e. a rise in the relative price of non-traded goods in terms of traded goods), therefore the non-oil traded sector (typically the traditional manufacturing sector) is placed under pressure because its exports become unprofitable and uncompetitive and eventually fall away to be replaced by net oil exports.

The consequences of a natural resource discovery or of favourable price changes in one sector of the economy are, at least initially, beneficial and amount to a Pareto improvement of the economy as a whole. However, as Neary and van Wijnbergen (1986) outline, the term "disease", and consequently the need for some form of government intervention, arises from the concern that exists over the distribution of the gains, over the issue of whether transitional assistance should be offered to declining sectors and over the issue of the appropriate response to various market failures which may impede smooth adjustment of the economy to its new equilibrium.

In Mexico, despite a policy objective of reducing dependence on oil (see point 6 of the NEP of section 1.3), the volume of non-oil exports contracted during the period 1974-85. The share of manufacturing exports in

---

[8] See, for example, Gillis (1978,1980), Corden and Neary (1982), Buiter and Purvis (1983), van Wijnbergen (1984a,b), and Neary and van Wijnbergen (1986).

total merchandise exports declined from 53 percent in 1974 to 24 percent in 1985; whereas the participation of oil and gas exports in the total increased from 4 to 70 percent in the same period.

In the future reviving Mexican economic growth will require strong export growth. Among non-oil exports, the fastest growing sector is, at present, the manufacturing sector whose exports jumped from 24 percent in 1985 to almost 50 percent of total merchandise exports in 1987 [9]. One of the main reasons behind the recent dynamism shown by manufacturing exports is the government's decision to change the orientation of the industrial plant from the domestic into the foreign looking market [10].

During the last three years a variety of programmes have been implemented to increase both the efficiency and the exposure of domestic industry to international markets aiming to encourage non-oil exports. An export development programme (Profiex) was introduced in 1985 with the objective of promoting manufactured exports by reducing any anti-export biases. Exports are charged a zero value added tax rate. This allows exports to enter world markets free of domestic indirect taxes. Profiex also introduced the possibility of importing inputs free

---

[9] An important share of export revenues now also comes from in-bond or maquiladora exports as well as from tourist industries. By contrast, agricultural exports have steadily fallen since the 1970s, reaching only 7 percent of merchandise exports in 1987.
[10] The other reason behind the increasing participation of the manufacturing sector in total exports is, of course, the fall in the price of oil and the consequent reduction in oil export revenues.

of duties. This is now granted not only to final product exporters, but also to their suppliers.

In 1986 what has been called the Domestic Letter of Credit was introduced. This allows suppliers of inputs to exporters to have foreign exchange for imports, export credits and duty-free imports for export promotion. On top of that, as was mentioned before, in July 1986 Mexico finally joined the GATT [11] aiming: a) an increase in competition and consequently in economic efficiency; b) the geographic decentralization of economic activities; c) an increase of access and diversification of Mexico's export markets [12].

Exports of manufactured goods remain, however, highly concentrated as a result of the industrial strategy of the past decades. In 1987 three subsectors accounted for nearly 60 percent of total non-petroleum manufactured exports: food products represented 13.4 percent, chemical products 11.1 percent, and transport equipment 33.9 percent [13]. On the other hand, most of Mexico's imports come from the capital-goods industry, the less developed sector of the industry. Manufactured imports accounted

---

[11] As Bucay and Perez Motta (1987) explain, during 1979 the Mexican government began negotiations to join the GATT but groups opposed stressed the fact that Mexico would no longer be able to use mechanisms of industrial support, like subsidies to exports, and that this would imply a loss of economic independence and would in turn represent a reduction in the number of instruments with which to attain economic objectives in a country where the existence of imperfect markets calls for government intervention. This coupled with the fact that Mexico was emerging as an oil exporter, in March 1980 Lopez Portillo announced that Mexico would not join the GATT.

[12] For an analysis of the advantages of joining the GATT, for the case of Mexico, see Gabinete de Comercio Exterior (1986).

[13] These and the following figures of this paragraph were obtained from Comercio Exterior (febrero, 1988).

for 92 percent of total imports in 1975 and by 1987 they still were 88.1 percent. Among the main manufactured imports are: machinery and equipment making up 33.4 percent of total imports, transport and communications equipment with 14.4 percent, and chemicals with 11.3 percent (Banco de Mexico, 1988).

Although in the next few years the oil sector is not expected to yield foreign exchange at levels comparable with the 1974-85 period, oil revenues will still represent a major share of total exports. Therefore, this work is interested in assessing the effects of different oil prices, production and exports scenarios, on the performance of the two main components of manufacturing exports: capital and the rest of manufacturing goods. As shall be explained in section 5.2 the model constructed here allows for the endogenous determination of both oil and manufacturing exports according to the exogenously projected prices, needs for foreign exchange, oil export ceilings, and so forth. Thus, an evaluation can be made as to what extent manufacturing exports lose (gain) their foreign markets because of the increased (decreased) domestic costs and the real appreciation (depreciation) of the exchange rate due in part to the behaviour of oil exports and prices.

2.2 Energy Policy - Labour Force.

Mexico, as most oil exporting countries, saw an unparalleled growth in the size of the public sector and experienced a considerable extension of its role towards direct participation in industrial production. This phenomenon caused substantially adverse effects on the diversification of investments since the government's investment programme was largely directed towards hydrocarbons. Many of these projects, as Gelb (1985a) explains, were large, complex and tended to overrun initial estimates both in terms of cost and time which ultimately meant that many projects are still under construction or never reached completion (Murphy, 1983). Also, increased construction costs were a major factor in the real appreciation of the exchange rate.

Table 2.2 captures the growing share of the public sector in economic activity by looking at the trend of two indicators: the share of value added in the government sector in GDP and the share of total investment which is done by the public sector. The maximum public sector participation occurred during the 1975-84 period which in part originated the debt crisis.

Table 2.2
Public Sector Value Added in Mexico, 1965-1986.

Period	Value Added as Percent of GDP	Share in Total Investment
1965-1969	11.7	37.5
1970-1975	14.5	33.6
1975-1979	19.4	41.9
1980-1984	26.3	44.0
1985-1986	23.9	36.3

Source: Dornbusch (1988, Table 3, p.7).

Gelb (1985a) concludes that the multiplier effects of investment expenditures, cost overruns, subsidy growth and the recurrent spending needs of much past investment, all resulted in a tendency to overshoot available oil reserves when the latter fall. Further, the massive infrastructural and educational investments, whatever their implications for future productivity, did not give rise to an autonomous source of income to replace oil revenues.

More importantly, such projects were frequently highly capital intensive and many industries which have benefited from cheap oil such as fertilizers, iron and steel, glass and cement, are also capital intensive. This occurred at a time when the economy needed to absorb the growing labour force. During the 1982-87 period, the labour force increased annually at a rate of 3.5 percent, whereas employment's annual rate was only about 0.2 percent for the same period (SHCP, 1987). Not surprisingly, the official unemployment rate jumped from about 5 percent in 1982 to an estimated 18 percent in 1987, with a further third of the labour force underemployed.

As Chenery (1974) has shown, since employment growth is the main channel through which income distribution is improved, the distribution in Mexico has worsened even further during the 1980s (in the late 1970s, the latest period for which data are available, the top 5 percent of households received 25 percent of all incomes) [14]. The World Bank (1987) estimates that by 1986, 20 percent of

[14] See World Bank (1987) and SPP (1986).

the labour force was absorbed by the informal sector or was employed in the U.S. Above all, given the fact that in the years ahead the labour force is expected to increase even further (at about 3.6 percent), employment generation represents a major policy objective in Mexico.

The labour force in Mexico is, of course, not homogeneous. There are basically three types of labour; rural, non-skilled urban, and skilled urban labour. The 1980 Population Census reported that rural labour accounted for 33.2 percent of the total labour force, whereas non-skilled and skilled urban labour represented 26.7 and 40.1 percent, respectively of the total [15].

Given that the skill-mix differs substantially among alternative investment projects, a key energy-labour force interaction to be addressed here consists in analyzing how different energy policy scenarios affect the allocation of capital and the three types of labour throughout the economy.

In addition, given that skilled labor is the most demanded and relatively scarce labour group, a relevant issue to be examined in this work are the effects of skilled labour force restrictions in terms of GDP and sectorial growth, the allocation of investment, and in particular on the ability of the economy to absorb oil revenues.

[15] This Census classifies as rural, the labour force living in areas of less than 2,500 inhabitants. Otherwise, the labour force was considered as urban.

2.3 Energy Policy - Foreign Debt.

In the 1950-80 period, Mexico's external deficits were on average only 1 percent of GDP (Dornbusch, 1988), and part of these deficits were financed by direct foreign investment [16]. In 1973, for example, $3.1 billion accounted for direct foreign investment stock against $10 billion of external debt. Consequently, during this period there was no significant build up of external debt. This point is very strongly reinforced by the external debt ratio. In the early 1970s it was less than 20 percent of GDP, and despite the fact that there was a small bulge in 1976-77 associated with the financial crisis of that period, even by 1980 the debt ratio was less than 30 percent of GDP (Banco de Mexico, 1988).

The large run up in debt is concentrated in the 1981-82 period when the debt ratio climbed to almost 60 percent of GDP (SHCP, 1988). The net external indebtedness incurred during 1981 and 1982 was about $31,778 million (SHCP, 1988), which means that nearly a third of the total external debt that Mexico owed to its creditors at the end of 1987 ($105,000 million) was contracted in those two years.

As was commented before, one of the main reasons which explain the increasing reliance on external debt to finance economic development in Mexico is the fact that

---

[16] For Mexican debt history of the 19th and 20th century see Turlington (1930), Tellez (1985) and Vogelsang (1987).

during the late 1970s and early 1980s the public and private sectors became increasingly dependent on oil exports to meet their foreign currency requirements. The downturn in world oil markets after 1981 revealed the real degree of oil addiction of the entire Mexican economy, showing that the domestic savings, by then mostly due to oil revenues, were insufficient to cover the country's investment needs. This in turn led to the debt crisis of 1982: bank lending came to an abrupt end in May-June of that year. With no new credits available to roll the maturing principal and the interest payments, in August 1982 Mexico declared a moratorium. Then, in 1983 under de la Madrid's administration Mexico signed a three-year stabilization programme with the IMF.

Principal payments during the 1983-87 period were consistently smaller than those originally established as a result of the new terms agreed upon by Mexico and its foreign creditors. The Mexican government and other public sector entities signed an amended restructure agreement covering $48.9 billion of public sector debt to commercial banks, obtaining better terms and conditions [17]. A large portion of private sector external debt was also restructured [18].

---

[17] In 1987, 99.3 percent of total public external debt corresponded to long-term loans and only the remaining 0.7 percent consisted of debt to be paid in less than a year time (SHCP, 1988).
[18] At the end of 1982 private external debt was $18 billion. The government of de la Madrid provided under the Ficorca regime, an exchange risk guarantee and peso financing for those firms who restructured their long-term debt (beyond 8 years for principal, with a 4 year grace period).

Yet in contrast to the trend of principal payments, interest payments remained quite large. For the 1983-87 period interest payments totalled an estimated $48.4 billion as compared with a net indebtedness of about $8.1 billion. Also, the errors and omissions item of the balance of payments, which is commonly associated with estimates of capital flight, suggests that this amounted to $9.5 billion during 1982-86 (IFS, 1988) [19]. Moreover, in the last two years the overvalued currency and nervousness about the new administration of Salinas de Gortari have combined to encourage capital flight which, in turn, has meant a reduction in the level of reserves [20].

All these factors led to an unprecedented net transfer of resources from Mexico to its foreign creditors of an estimated $40.3 billion or about 6 percent of GDP for the 1983-1987 period. Figure 2.1 captures the net resource transfers as a percent of GDP from 1960 to 1988.

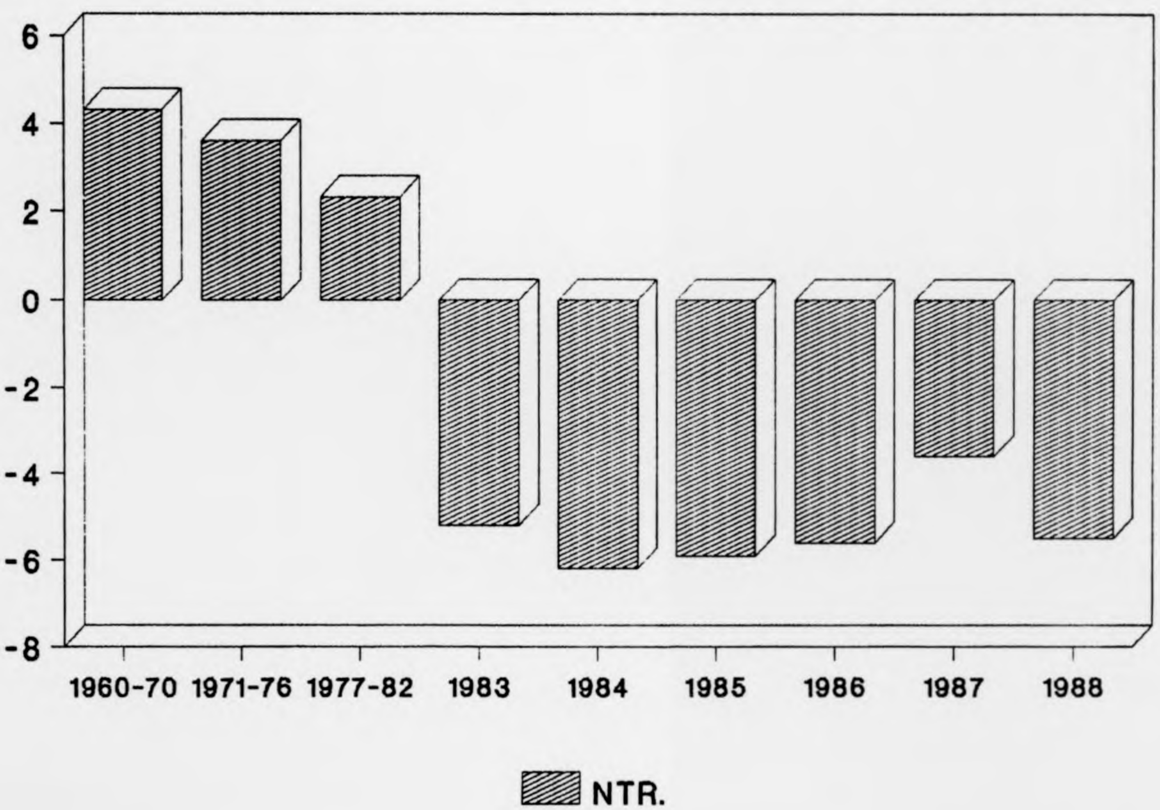
The large net outward resource transfers of the past five years came to a large extent at the expense of investment, and as a result, the Mexican economy faces today very strong limitations to growth. Table 2.3 shows an index of real investment spending. Outside

[19] Morgan Guaranty Trust, one of the main creditor banks for Mexico, estimates that $20 billion in capital left the country in 1982-1987. According to this source, Mexico is also the leading nation among the 15 principal middle-income LDC in financial difficulties in terms of capital outflows during 1977-87, followed by Venezuela.

[20] Recently Mexico has announced special tax treatment for investment returning to the country in an attempt to lure back capital flight.

Figure 2.1

Net Transfer of Resources, 1960-1988.
(Percentage of GDP).



Source: SHCP, 1988.

construction, which was urgently required because of the 1985 earthquakes, investment in machinery and equipment and total investment have declined dramatically to the levels of a decade ago. As Dornbusch (1988) states, with a labour force growth of more than 3.5 percent, failure to expand capital at rapid rate implies a growing, acute imbalance between capacity and high-employment capacity requirements. Moreover, the lack of investment builds up bottlenecks in infrastructure which stand in the way of the resumption of growth.

Table 2.3
Real Fixed Investment, 1970-1986
(Index 1970=100)

Period	Total	Construction	Machinery & Equipment
1970-1974	114	112	116
1975-1979	159	156	163
1980-1984	202	202	203
1985	174	187	156
1986	153	170	131

Source: Dornbusch (1988, Table 15, p.42).

Because of the burden of debt service, the government has tried to reduce the level of external debt so as to tailor debt service to the country's payment capacity. Using the significant discounts offered at the secondary market for developing countries debt, two market-related mechanisms: debt-equity swaps and buy-backs bonds, have been implemented so far by the financial authorities, aiming to reconcile debt service and growth.

It is estimated that the swap programme had retired about $2.6 billion in government debt since its 1986 inception, and until its suspension in 1987 because of the inflationary impact of the monetary growth it generated [21]. On the other hand, in March 1988 20-year Mexican government bonds were swapped at an average 30 percent discount for $3.7 billion in outstanding loans, in effect striking $1.1 billion in debt from books. With a yield of about 10.5 percent, the US zero-coupon issue cost the Mexican exchequer $492 million (Financial Times, 7th April 1988) [22].

Petroleum-tied bonds are among a range of proposals currently under study in the Finance Ministry of Mexico, where a link to oil prices (and not to oil reserves as some US bankers suggested) would be employed as a measure of Mexico's ability to pay (SHCP, 1988). Above all, some economists have proposed the recycling of interest payments to finance reconstruction and development in Mexico (see Dornbusch, op. cit.). This scheme basically amounts to a debt-equity swap applied to interest payments rather than to the principal and would extend

---

[21] As Dornbusch (1988, p.47) concludes, the success of debt-equity swaps for debtor countries depends on a variety of features: "In the extreme, debt equity swaps may merely replace investment that would have occurred anyway, leaving the authorities without any significant share in the discount while requiring the financing of the local currency payment via money creation or expensive domestic debt finance. At the other extreme, the discount may be the leverage that provides foreign investment with the required return, while the authorities share in the discount to an extent that reduces effective interest payments". At the same time, since debt-equity swaps give rise to future profit remittances, the balance of payments effect is a reduced outflow of interest payments but an increased outflow of profit remittances. There is no presumption that the net effect should be favourable for the debtor country.

[22] Dornbusch (1988, p.49) explains that the scope for buy-backs is, however, intrinsically limited: "to be able to buy back on a large scale the debtor needs resources which, if they are available and will be used, would mean that the claim does not trade at a large discount".

over a decade or so [23]. In short, all these mechanisms are means for the country to have the resources for growth while still honoring external debt commitments.

Moreover, as stated before, due to the instability of the world oil market, in 1987 a new strategy towards debt financing was set between the Mexican government and the IMF. This strategy links external financing to the variations in oil prices. This mechanism provides that, if the international price of the Mexican oil were to fluctuate between $9 and $14 per barrel in a given quarter, the net external financing to the public sector would remain as planned. If prices move above $14 per barrel, net external financing would be reduced by the resulting additional revenue, and if prices drop below $9 per barrel, external financing would be increased. The additional foreign financing was on a one-to-one basis during the first nine months of the programme, thereafter any shortfall in oil revenues would be absorbed by a combination of domestic adjustment and increased external financing (SHCP, 1987).

Nowadays, the new administration of Salinas de Gortari, in accordance with the Brady proposal for third-world debt reduction, is seeking a significant debt

[23] According to Dornbusch (1988), the advantages of the recycling of interest payments would be threefold: first, the transfer abroad of resources is suspended and are shifted toward investment which would imply an expansion in capacity and job creation. Second, it would create a more stable and prosperous business environment. This would promote the return of capital flight. Third, it would provide a breathing space for stabilization of inflation since the removal of external constraints allows some real appreciation. As a counterpart, Mexico would have to sustain the budget improvement and to liberalize the scope for foreign direct investment.

and/or debt service reduction from the creditor banks. There have been some problems in the negotiations [24] partly because of the assumptions made about the pattern of oil prices and interest rates. Briefly, Mexico's $12 per barrel assumption for 1989 is considered too low, while Mexico has complained about the increase in dollar interest rates of the past months.

To summarize, Mexico's future needs for foreign borrowing will essentially be determined by the behaviour of two variables in particular: the future trend of world oil prices and the future pattern of interest rates on foreign debt. On the other hand, as noted before, the Mexican authorities have imposed crude export ceilings since the rediscovery of the oil wealth. Actually this export ceiling was reduced from 1.5 mb/d of crude oil between 1980-86 to its actual level of about 1.3 mb/d despite the collapse of world oil prices, the reduced domestic demand because of the depressed economic activity, and Mexico's urgent needs for foreign exchange [25].

Hence, there are several important questions regarding the interaction between energy-foreign debt. Among them, the following are perhaps of particular importance and represent the issues to be addressed here.

---

[24] Banks can choose from four options and these are described in section 7.6.

[25] Although not a member of Opec, Mexico has decided to help 'stabilize' the international oil market by restraining exports.

First, under different oil prices and interest rates scenarios, and particularly, under the current conditions of the world oil market and the debt service burden that Mexico faces nowadays, is the fixing of crude export ceilings compatible with the country's needs for foreign exchange in order to meet, simultaneously, the principal and interest payments as well as the imports and some other domestic expenditures indispensable for the recovery of economic growth? If not, what range should Mexico establish for flexible growth rates of crude exports to be used as a point of reference in the years to come in accordance with higher costs of foreign borrowing, lower oil prices than previously expected, the current oil industry potential, and a reasonable level of oil reserves?

Second, given the currently depressed oil market (and the fact that today oil revenues represent a significant part of Mexico's domestic resources), and given that nowadays lenders want to see a reduction in absolute exposure (i.e. a reduction in the debt-income ratio which means less external loans), is Mexico's present full external debt service policy compatible with economic growth rates above, for example, the labour force growth?

Third, as already indicated, Mexican authorities are seeking to reduce a high proportion of the level of accumulated foreign debt that is owed to the commercial banks. What would then be the effect of a reduction in the level of external debt on the performance of the economy?

Fourth, since Mexico's future needs for foreign borrowing are crucially determined by the behaviour of two variables in particular: interest rates and the price of oil, an important issue that this research aims to evaluate is the impact of more favourable external conditions (i.e. a fall in the interest rate on foreign debt and a rise in the price of oil), on the Mexican economy.

The above are some of the relevant long-term development questions about the interactions between energy and the economy in Mexico, on which the present study shall focus. At the same time, the intertemporal structure of the anticipated time path of oil revenues will allow to evaluate a series of fundamental questions faced by the Mexican economy over the next two decades. For instance, in what assets should Mexico save and invest? The country's total wealth can be decomposed into three types of assets: (i) real capital assets (factories, infrastructure, etc); (ii) oil and gas reserves; and (iii) financial claims on the rest of the world. In this context, oil extraction decumulates the second and foreign borrowing the third type of wealth. Therefore, a crucial question is: how much of current income should go to accumulation of foreign assets, reduction of foreign borrowing or even retirement of foreign debt? Similarly, how much of savings should be allocated to investment, and in which sectors? The answers to these questions depend on several factors such as the return that the society can get on additional investment, on the consumption requirements that must be satisfied, on society's long-term willingness to save and on the terms on which domestic resources can be complemented by foreign capital. Trying to determine the optimal composition of investment also represents a complex issue. Should the emphasis be on social infrastructure, schools, etc, or do export producing and import competing commodity producing sectors deserve top priority? Though there may never be ideal answers to such issues, it is hoped that the model presented here can bring out some of the essential features of the strategic choices that must be made.

While this thesis will discuss "optimal" growth rates, the primary objective of the research is to analyze the interdependence between the decisions of the different actors of the economy, and to test the sensitivity of optimal policy rules to key exogenous variables as the world price of oil and the interest rate on foreign debt. It should also be stressed that the model is designed as a laboratory for policy experiments and not as a forecasting model.

Another important objective of this work is to provide insights into the price structure that should accompany an optimal strategy. In particular this work will be looking at the behaviour of two macroeconomic prices: the real exchange rate and the real wage. As already stated, these relative prices may vary over time so that their time path is important for the analysis of trade and current account movements, as well as for investment and project appraisal procedures.

Moreover, the economic model that will support the analysis yields shadow prices for each of its constraints, so that implications for the relation between the price of domestic goods and services and foreign exchange, for example, can be derived. In principle then, the shadow prices obtained from the dual solution of the model can become useful inputs into more detailed sectorial estimates of shadow prices, by providing the link between long-run optimal growth considerations and the more partial sector studies.

In the next chapter some of the most representative studies both theoretical and empirical are reviewed. Chapters IV and V will then explain the kind of analytical framework that is needed in order to analyze the above-mentioned energy-economy issues.

CHAPTER III.

THEORETICAL AND QUANTITATIVE ENERGY MODELLING:
A REVIEW OF THE LITERATURE.

This chapter presents a synthesis of the main conclusions to be drawn from theoretical writings on the relations between natural resources and the macroeconomy, as well as a review of some of the representative research carried out in the area of quantitative energy modelling before and after the oil boom of 1973-74.

The plan of this chapter is as follows: Section 3.1 briefly describes the nature of applied energy policy modelling before the first oil boom. Section 3.2 then summarizes some of the more representative theoretical and quantitative energy models developed after 1973-74, and assesses the pros and cons of the basic economy-wide approaches adopted by the subsequent quantitative studies which have been built on the basis of the new theories.

3.1 Pre-Oil Boom Quantitative Energy Modelling.

The desirability of careful modelling of energy policy analysis has long been recognized [1]. Energy forecasting, for example, has always had its practitioners, particularly when examining the balance between energy supply and demand [2].

[1] Some representative pre-embargo energy research is contained in Macrakis (1974).
[2] Over a century ago, for example, the English economist Jevons predicted that Britain would run out of coal, thus cutting off the industrial revolution.

Before the first oil boom, however, as Hudson and Jorgenson (1974) comment, applied energy studies basically consisted of either econometric or fixed coefficient Input-Output models. Econometric models in the Tinbergen-Klein mould, while useful in studying the impact of economic policy on aggregate demand, did not provide an adequate basis for assessing the impact of economic policy on supply.

On the other hand, in the 1950s and 1960s Input-Output (I-O, hereafter) analysis, in the form originated by Leontief, and linear programming models, had been useful in analyzing the supply side predicated on a fixed technology at any point of time, but did not provide a means for assessing the impact of changes in technology induced by price variations associated with changes in economic policy.

In the case of Mexico, the best compendium of this latter type of models is found in Goreux and Manne (eds.) (1973) who review seven linear programming models constructed at different levels of aggregation. At the highest level, there are two economy-wide models (Dinamico and Exporta), which are based on an I-O framework and do not allow for technological choices within sectors (except for agriculture in Dinamico), or substitutability between inputs [3]. On the demand side, Dinamico and Exporta, as any other I-O model of that time, do not deal with substitution effects, that is, the

[3] Dinamico was constructed by Manne (1973), while Exporta was conceived by Trejo-Reyes (1973).

composition of the consumption-mix is not allowed to vary in response to changes in product prices. Moreover, these models cannot choose between domestic production and imports (all imports are viewed as non-competitive), while upper bounds on exports are specified. All of which leads to a very rigid structure of commodity balances.

At the intermediate level of aggregation, there is one sectorial model for energy (Energeticos) which covers steel, electricity, and petroleum [4]. This model allows for some degree of substitution between alternative processes within Mexico's energy producing industries. On the demand side, as in the case for the economy-wide models, final demands for the output in each of the sectors are constrained to vary in fixed proportions, although there is some choice in the export-mix and import-mix. At the lowest level of aggregation, Intercon, which is a regionally disaggregated model, introduces tradeoffs between electricity generation and transmission lines. Domestic demand is exogenous [5].

Dinamico and Energeticos were optimized dynamically while, for Intercon, recursive optimization was used. For the other four models, the optimization refers to a single target year [6]. The energy models were used for analyzing investment choices in the petroleum and

---

[4] For more about Energeticos, see Fernandez de la Garza and Manne (1973).

[5] Fernandez de la Garza, Manne, and Valencia (1973) constructed Intercon.

[6] The other three linear programming models are: Chac developed by Duloy and Norton (1973); Bajio by Bassoco, Duloy, Norton and Winkelmann (1973); and Pacifico by Kutcher (1973).

electric power industries. The choice between nuclear and fossil electric power plants was assessed by Energeticos in terms of the impact upon the domestic demand for petroleum products, while the problem of location was studied in Intercon. Dinamico, on the other hand, using five labour-skill categories and incorporating labour-skill substitution, evaluates the effects of labour constraints on growth, consumption and foreign capital inflows for the 1968-86 period.

In other countries, particularly developed countries, a host of econometric and I-O models were used to predict energy use. Hitch (1977) discusses some of the assumptions used by these energy studies. He outlines the fact that most of them used short-run price elasticities which were small in absolute terms and small in relation to long-run elasticities. Furthermore, since it was also a common practice to use I-O coefficients which were not price-sensitive, there was almost no room for any kind of substitution and, consequently, virtually all structural relationships in these models remained unchanged, particularly energy demand.

Not surprisingly, the main conclusion of these models was that energy use would continue to increase as rapidly in the future as it had in the past and would be affected little by price increases. Therefore, the unexpected 400 percent increase in world petroleum prices associated with the Arab oil embargo of October 1973 and its recessionary impact on the world economy, highlighted even more the need for a new approach to the analysis of energy policy in Mexico.

3.2 Post-Oil Boom Theoretical and Quantitative Energy Modelling.

After the first oil boom, a reappraisal of the energy situation and the capabilities of existing energy models, both theoretical and quantitative, became essential. This section will refer first to the former type of models.

Natural Resources and the Macroeconomy: Review of Theoretical Models [7].

The magnitude of the shocks to both resource-poor and resource-rich countries occasioned by changes in the price of natural resources during the 1970s and 1980s gave birth to a sizable number of theoretical writings which attempt to explain the different effects of resource booms on the macroeconomy. Existing models from the theories of international trade, open-economy macro-economics and natural resource depletion, have been extended to study the macroeconomic problems faced by both resource-exporting and resource-importing countries.

At first, attention was paid to the macro issues raised by higher oil prices in oil-importing economies. Then, resource-based booms were blamed for a tendency towards 'deindustrialization', unemployment and other bottlenecks which triggered a large and growing literature on the macroeconomic problems faced by oil

[7] This sub-section is based on Neary and van Wijnbergen (eds.) (1986). For a description of the bibliography about Dutch Disease and related topics see also Harberger (1983).

exporters. As Mexico belongs to this latter category, this section will concentrate on the literature relevant to such cases.

To begin with, this section will comment on Jones's (1986) assessment of how the Dutch Disease phenomenon is intimately linked to the basic concept of comparative advantage. In a simple Ricardian world it is generally the case that any one small price-taking country needs to produce only one traded commodity (the one with the highest value in international prices per unit input), and can rely on trade to satisfy its consumption needs. If a natural resource boom takes the form of raising labour's productivity (labour being the single input) in a commodity previously imported, to such an extent that value per unit of labour input exceeds that in the traditional export sector, then the law of comparative advantage is ruthless in casting aside the original export industry, despite the fact that this industry has not lost any of its absolute productivity advantage vis-a-vis other countries. In other words, since the essence of comparative advantage is that a sector is locally viable only if it retains its productive superiority compared with other sectors of the same economy then, in the one factor Ricardian model, a boom in one tradeable sector means that only one industry survives.

Sector-specific and/or Heckscher-Ohlin models allow more than one traded activity to survive and are, therefore, usually favoured in discussing the Dutch

Disease phenomenon. For example, in a two-sector specific factors model, a boom (productivity increase) in the import-competing sector can cause labour to be reallocated from the traditional export sector and a switch in the trade pattern without completely wiping out the former export sector. In a model with more than one factor but only two traded goods, a price rise in a booming sector, or an expansion in the supply of a resource which is used only by that sector, must have the effect of dragging resources away from the other sector at given world prices.

The possibility of a complementary relationship between outputs in the booming sector and a traditional sector requires the existence of more than two tradeables. One such example was provided by Gruen and Corden (1970). In their model they suppose that the booming sector requires labour and capital. The supply of capital is fixed; the booming sector can draw labour from the rest of the economy, consisting of two other sectors, each requiring labour and land. At initial prices, the Rybczynski effect declares that one of these sectors loses resources but the other actually expands rather than suffer a Dutch Disease contraction.

All these models assume that the booming sector produces a final consumption good. If, instead, the booming sector produces an input required by the traditional tradeable sector, will the latter be favourably affected? As Jones (1986) explains, the role of international trade is crucial in answering this question. A boom in an input-producing sector that is non-tradeable (or if the government subsidizes energy, as has been the case in Mexico) may well encourage output expansion in traditional tradeables employing this input. But if the input is traded and its price is prevented from falling, traditional tradeables (as an aggregate) are adversely affected in the Dutch Disease manner.

In the case where traditional tradeables use other specific inputs that are themselves traded on world markets, one aspect of the Dutch Disease is avoided: the return to these specific factors is not driven down (in the small-country case). However, a different aspect of the Dutch Disease is exacerbated through the cross-hauling phenomenon: a boom in one sector may attract capital from abroad while, via its effect on local input prices, it drives out other traded inputs as their returns threaten to fall [8]. Jones (1986) also analyzes cases where elements of positive externalities and increasing returns to scale may provide the basis for a non-Dutch Disease outcome. In such a scenario a boom in one sector attracts resources into industries capable of supplying this sector and induced expansion may encourage development in a wider range of industries.

The impact of a sudden increase of exogenous foreign exchange flows on the structure of the economy has traditionally been described with the help of a simple

[8] For details see Caves (1977) and Jones et al. (1983).

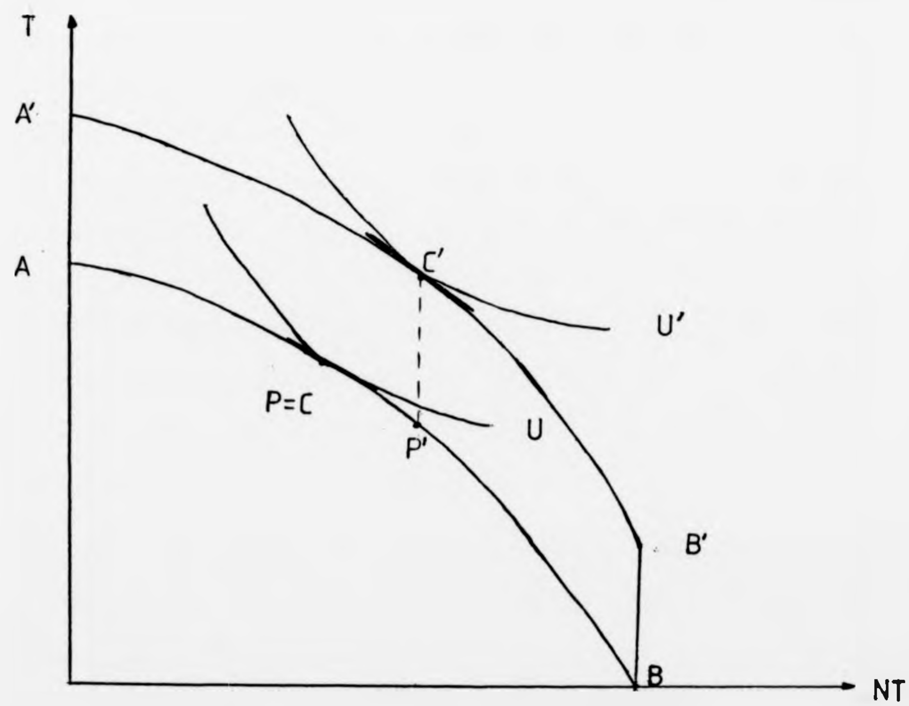
two sector model (see Buiter and Purvis (1982), Corden and Neary (1982), van Wijnbergen (1980, 1981), and Dervis et al. (1984)). These authors basically define as "exogenous resources" the sum of oil and gas revenues and net foreign capital inflows. This term does not mean that their magnitude is totally unresponsive to domestic economic policy. They are called "exogenous" more in the sense of having very little to do with the productivity of an economy's labour force that is traditionally employed in agriculture, industry and services. It is also true that their magnitude is very much dependent on factors beyond the policy makers' control such as world oil prices, etc.

On the other hand, while there are some significant differences between oil revenues and foreign aid flows, both basically represent a transfer and, as stated before, their magnitude bears very little relationship to productivity, wages and resource growth in the non-oil domestic economy. Moreover, the transfer accrues in the form of foreign exchange and, therefore, implies immediate command over resources that are tradeable on the world market. An increase in exogenous foreign exchange resources implies an immediate increase in the capacity of a country to consume traded commodities and services. For non-tradeable commodities, however, availability of foreign exchange does not signify an immediate increase in potential consumption since their supply can only be increased by raising domestic production.

Figure 3.1 reproduces the by now well established stylized representation of the impact effect of a foreign transfer. The economy outside the resource sector is divided into two sectors: traded (T) and non-traded (NT). In the absence of any other resources, the production possibility frontier AB is also the consumption possibility frontier and the economy will produce and consume at P=C. The slope of the production possibility frontier at P=C defines the equilibrium relative price of NT in terms of T, a price that is defined as the real exchange rate.

Figure 3.1

The Impact Effect of an Exogenous Resource Transfer.



Source: Dervis, Martin and van Wijnbergen (1984, Figure 2, p.11).

Now assume that this economy all of a sudden receives an exogenous resource transfer in the form of an increase in export revenues from oil. The production possibility frontier does not change since the capacity to produce T or NT is not immediately affected by this transfer. But given any point on AB, the economy can now increase its consumption of T by an amount AA′ by importing simply from abroad. On the other hand, the economy's ability to consume NT remains constrained by domestic productive capacity.

The consumption possibility frontier, therefore, shifts vertically to A′B′B and consumption and production after the transfer will be at C′ and P′ respectively. As income has risen, the economy consumes more of both T and NT (real income goes from U to U′). To achieve this, more NT must be produced. This implies shifting resources out of T into the NT sector. This shift, in turn, requires a rise in the relative price of NT, that is, a real appreciation of the exchange rate (i.e. relative price of NT), so that the initial imbalance is corrected by an increase in the supply of NT goods and a reduction in demand for them, both brought about by an increase in their relative price [9].

The magnitude of the real appreciation depends on how easy it is to substitute in consumption NT and T goods,

[9] While the model is usually discussed with reference to a positive transfer of resources, the same analysis, in reverse, applies when a country loses foreign resources. The shift would be from P′ and C′ to P=C, reflecting a loss in real income, a shift of resources into T and a rise in their relative price or real depreciation.

and on the curvature of the consumption possibility set A'B'B. This possibility set equals the vertical sum of the transfer and the production possibility frontier, so its curvature is determined by the curvature of the latter. This curvature is probably larger in the short run, as existent sector specific equipment, machines, skilled labour, etc, are not easily shifted from one type of production to another. In the medium run, though, the stock of capital and labour in each sector can be adapted via depreciation, new investment, training, etc., so that the long-run transformation curve is likely to be flatter than the short-run frontier. Also, in the longer run population growth and accumulation of physical capital shifts the frontier AB over time. In a forward-looking model, the change in relative prices due to the transfer, as well as future changes, will affect the magnitude and allocation of investment, as will be discussed in chapter VI.

This simple theoretical model of an economy can provide the basic framework for an analysis of the Mexican economy, because, as argued in the previous chapters, it seems that the challenge that Mexico now faces arises from the need to gradually shift the engine of growth from a "natural resource" and "foreign resource" base, to a growth path which derives from the expansion of the domestic non-oil economy.

Neary and van Wijnbergen, (N-vW hereafter) (1986), present the most comprehensive synthesis of theoretical writings on natural resources and the macroeconomy for the case of an oil-exporting country. Various models, using different assumption, analyze some other aspects of the Dutch Disease phenomenon, such as unemployment, deindustrialization, and subsidies.

In the simplest static model abstracting from monetary considerations, assuming perfect flexible wage rates and two sectors: traded and non-traded; a resource boom affects the economy in two ways. First, there is the 'spending effect': to the extent that some oil revenues are spent on NT, this bids up their price, which implies that the higher relative price of NT goods makes domestic production of T goods (e.g. manufacturing industry goods) less attractive and so their output declines leading to deindustrialization. Second, there is the 'resource-movement effect': as the oil sector becomes more profitable, it draws resources away from the other sectors. Since the price of tradeables is given by the world price, this movement of resources reinforces the tendencies towards appreciation of the real exchange rate (a rise in the relative price of NT), and to the contraction of the tradeable sector [10].

In addition to its effect on sectorial structure, a booming resource sector has also been identified as a cause of unemployment. N-vW identify two cases in which a resource discovery (or, equivalently, exogenous increases

[10] Once the new equilibrium is reached there is also an increase in welfare which means that, as explained in section 3.1, the initial impact of any oil boom amounts to a Pareto improvement for the economy as a whole.

in the prices faced by resource-exporting countries) can lead to unemployment. Both cases are analyzed in static frameworks. Here, attention is paid to the first of these cases only since the other involves pure nominal rigidity, that is, it incorporates monetary consequences of a resource discovery and, as such, lies outside the scope of the present study.

The relevant case then, considers only those aspects of the Dutch Disease that concern the allocation of real resources and ignores monetary consequences. It also assumes wage and price rigidities in the manner familiar from the disequilibrium or fix-price macroeconomic literature [11]. The analysis is restricted to the case where the boom has a spending effect only. In these circumstances, unemployment may emerge if the rise in prices of non-traded goods requires a fall in workers' real wages but because of pre-existing contracts or trade union power real wages are downwardly sticky. Classical unemployment, as defined by Malinvaud (1977), will emerge because firms refuse to supply as much as demanded (there is excess demand for NT) not for lack of labour (there is excess supply of labour), but because real wages are too high.

In this model the crucial issue is the wage indexation rule which is adopted. N-vW (1986, p.23) state that "if the weight of non-traded goods in the consumption basket of wage-earners is 'more important' in demand than

[11] See Barro and Grossman (1971) and Malinvaud (1977).

supply, in the sense that the share of its output in the consumption of wage-earners must exceed its contribution to a weighted average of the supply elasticities of the two sectors, the real wage stickiness will give rise to transitional unemployment following a resource boom". Mexico would be an example of this situation since, until recently, it had a long history of prohibitive tariff barriers making many of its consumer goods virtually non-traded. Conversely, the countries of the Persian Gulf, many of which import almost all their consumption goods, experienced excess demand for labour after the oil price shocks.

Moreover, if the NT sector is capital intensive it will have problems absorbing all the workers made redundant in the T sector. However, if the resource-movement effect is included, then it is more likely that labour shortages rather than unemployment will emerge, since this provides a boost to the wage rate additional to that induced by the spending effect.

Although some aspects of the relations between natural resources and the macroeconomy can be examined in a static context, the most important questions arise from the intertemporal nature of resource booms. For example, issues related to the finiteness of oil reserves or from the adjustments to changes in energy policy require a dynamic perspective, so that it is necessary to develop a multi-period framework within which they can be analyzed.

N-vW, therefore, specify some dynamic models, consisting of two periods and the same two sectors as before.

Assuming no market imperfections or externalities, an oil boom leads to excess demands for the NT good in the two periods. With a normal price-output response, this increases the output of the NT good and reduces that of the T good in both periods. Hence, the implications of the simple static model -deindustrialization coupled with real appreciation-, continue to hold in the two period model.

With perfect foresight and perfect capital markets, the boom has the same effect on demand in the two periods, and the only difference between periods follows from the fact that the capital stock can be optimally adjusted in the second period but not in the first. This leads to a larger supply response of the NT good in the second period, and so to a future appreciation which is smaller than that in the current period. In this case, therefore, the oil boom leads to overshooting of the exchange rate in the short-run in the manner in which Neary and Purvis (1983) have shown.

Under these assumptions, N-vW conclude that the real appreciation is an efficient response to the increase in oil revenues, in the sense that it is essential to effect the allocation of factors of production out of the T goods sector into the NT goods sector which is necessary to accommodate the natural resource boom. It is a disease requiring treatment in the form of government intervention only if there is some market failure preventing the appropriate adjustment, or, if there is some existing immovable distortion which is exacerbated by the oil boom. The main conclusions of the above theoretical models can be summarized as follows:

(a). Deindustrialization, in the sense of a decline in output and employment in the exposed manufacturing sector, is a feature exhibited by all models considered. It is also a symptom of the economy's adjustment to its new equilibrium and in principle does not provide grounds for diagnosing a disease that requires corrective action. There are, however, some industries which are not exposed to foreign competition as a result of trade protection or that possess monopolistic price-setting powers in their export markets which may benefit from the rise in home demand caused by the oil boom.

(b). The models considered are also unanimous in predicting that a resource boom will give rise to a real appreciation: increase in the price of non-traded relative to traded goods.

(c). A necessary condition for a resource discovery to generate unemployment, is that there be some degree of wage rigidity.

In summary, these are just some of a variety of theoretical studies existing in the literature, which are helpful in understanding the effects of natural resource booms on the macroeconomy. Although no doubt this review is incomplete, it sets the scene for assessing the empirical studies which examine the steps in adjustment to changes in the price of oil in individual countries: that is the purpose of the following sub-section.

Post-Oil Boom Quantitative Energy Modelling.

During the early years following the first oil crisis, the majority of empirical studies concentrated on energy markets and discussed very specific issues such as forecasting and regulation. Fischer et al. (1975), for example, survey seven models which examine the future prospects for world oil prices and evaluate the economics of Opec [12]. In order to analyze these issues, two basic approaches were used: simulation and optimization models. In the former, the analysis was taken as occurring within either a comparative static or a recursive framework. In the optimization models, the decision makers were either the Opec cartel or all the individual members of Opec acting separately. In general, the main conclusion of all these models was that maintaining oil prices at or above current levels for any extended period of time was not in Opec's own self-interest, and that "prices ought to fall in the not too distant future" [13].

Also, in response to the historical events of 1973-74, some other studies analyzed different energy-related issues such as: optimal oil depletion (e.g. Bruno (1975), Aarrestad (1978), Cordoba (1979)); the international transmission of oil price effects (e.g. Marquez and Pauly (1984), Marquez (1986)); energy demand functions for particular countries (e.g. Choe (1978), Wolf et al. (1981)); environmental consequences of alternative energy

---

[12] The models are: Blitzer et al. (1975), Bohi and Russell (1975), the US Federal Energy Administration (1974), Kennedy (1974), Kalymon (1975), Levy (1974), and Nordhaus (1973).

[13] Fischer et al. (1975), point out that no models considered the very short-run, therefore, this conclusion should not be interpreted as saying that Opec acted irrationally in raising oil prices to their 1973-74 levels, or, even, that another price rise from these levels was unjustified. Although there was no general consensus about future price trajectories, all models pointed to $7 to $10 as the most likely range of oil prices, with general agreement on an expected value of about $8.50.

regimes (e.g. Behling et al. (1977), Ridker et al. (1977)); and so forth.

Some of these models, however, continued using pre-oil boom techniques such as I-O technologies without modifying the coefficients as functions of input prices. Above all, the majority of these studies employ partial equilibrium methods such as macroeconomic simulation models, technology assessment and energy sector assessment [14]. This means that energy demands were projected on the basis of exogenously forecast sectorial or macroeconomic growth, with or without sensitivity to variations in energy prices. In other words, partial equilibrium models view the energy sector in isolation from the remainder of the economy, and the analysis is performed without consideration of the broader impacts. Typically, the GDP and other macroeconomic indices are taken as given as though they are unaffected by the energy sector.

Manne and Hogan (1977, p.260), studying the impact of higher energy prices on US GDP, conclude that the direct effect of energy on growth crucially depends on the elasticity of substitution between energy and other inputs: "... if there is little energy substitution (below .3), the feedback effect is significant, and energy models must account for this effect in representing the energy system. However, if the substitution effects are significant (.3 or higher), the

[14] See, for example, Choe (1978) and Dunkerley (1982).

feedback effect on the evaluation of the energy system is relatively small. In this case, the energy sector may be analyzed by itself". Yet, most econometric estimates do not provide a conclusive answer to this issue since they range the substitution parameter between .2 and .6 [15].

Nevertheless, beyond the direct impact on GDP of higher energy prices for the case of energy-importing countries, two other effects have been emphasized as contributing to slower economic growth (Borges and Goulder, 1982): the savings-investment effect, consisting of the reduced capital accumulation as a consequence of lower rates of return to capital [16]; and the terms of trade effect associated with the higher oil prices, given that a substantial component of oil supply is imported [17].

The three channels through which energy can influence long-term growth naturally interact, for example, as GDP drops because of lower capital and labour productivity

[15] See, for example, Taylor (1976) and Berndt and Wood (1977).

[16] The savings effect follows from the finding that in many sectors of production capital and energy may be complements rather than substitutes. Then, if energy prices increase, the demand for capital decreases and the rate of return to capital decreases. If saving is responsive to the rate of return, the higher energy prices may translate into less investment and therefore slower growth. The magnitude of this effect thus depends on the degree of capital-energy complementarity, and on the elasticity of saving with respect to the rate of return.

[17] As imports become more expensive, additional resources must be diverted to pay for them, in particular through increased exports. This reduces what is left for consumption and investment and, therefore, lowers utility or welfare, current or future. Borges and Goulder (1982), explain that this effect distinguishes from the direct effect only to the extent that rents included in the energy prices are paid to foreigners and not to domestic producers or consumers. If the price of energy corresponds exactly to its cost, then there is no distinction between the two effects.

due to the direct effect, saving and capital accumulation will drop even if the rate of return to capital remained constant.

In short, many researchers today agree, and indeed empirical evidence has shown, that for many countries the feedback effects between energy and the economy are too important to be neglected. These interactions, as Blitzer and Eckaus (1986b) point out, probably are more significant for developing than developed countries because the former are in a weaker position to cushion any oil price shocks. At the same time, their economies are changing at a more rapid rate, generally characterized by increased industrial production and urbanization, both of which tend to be energy-intensive.

In the case of Mexico, chapter I explained the extensive feedback effects between energy policy and overall economic policy from a historical perspective. Particularly, chapter II highlighted the interactions between energy policy, industrialization, labour force and foreign debt as the three key long-term development issues that Mexico faces nowadays, and which represent the purpose of this study.

To sum up, the problem with partial equilibrium models is that they neglect the interactions between supply and demand, both within the energy markets as well as between the energy sector and the economy as a whole. Thus, this type of model only captures a one-way direction of the economic influences of energy policy: energy affecting the economy, or viceversa, but not back and forth. The most consistent way, then, to capture these interactions is to model the behaviour of all agents in a general equilibrium (GE) framework [18]. Next, some of the more representative GE models constructed for certain countries will be reviewed, which analyze various energy issues.

As Devarajan (1987) outlines, the application of GE models to natural resources mirrors three categories of questions. First are the questions that deal with the resource as an input to production. For instance, what is the impact of an increase in the world price of oil on the supply of and demand for oil as well as other sources of energy ? Models that try to answer this type of question are called Energy Management Models (EMM). Examples are: Hudson and Jorgenson (1974), Manne's ETA-Macro (1976), de Lucia and Jacoby (1982), Dixit and Newbery (1984), and Hughes (1986a,b). In general terms, these models contain a very detailed treatment of energy demand and supply, but they treat the rest of the economy in a fairly coarse fashion. The non-energy sector is frequently treated as exogenous.

A second category of questions and models relates to natural resources as the source of revenue to the country. Here, the issue is not the impact on input costs

[18] The discussion of the effects of a natural resource discovery in the theoretical models in section 3.2, also illustrates why it is a problem ripe for GE analysis. Both the resource movement and spending effects cannot be captured by a PE model. Moreover, relative price movements such as the exchange rate, are exactly the type of effects that GE models are designed to capture.

of an increase in the price of oil but rather the impact of increased export revenues on oil producers and governments. What are the effects of this "windfall" on the rest of the economy? These models represent the quantitative counterpart of the Dutch-Disease theoretical models reviewed previously. One of the best examples of this type of model is the work by Gelb (1985), who developed a CGE model of an Indonesia-like economy using a 1975 SAM, with the purpose of assessing the consequences of alternative policies for the use of oil windfall gains. Gelb's model consists of six sectors partitioned by their intrinsic tradeability, and divided between modern and traditional activities. Value added accrues to modern and traditional labour, incorporated and unincorporated capital and government. Production is determined through a combination of Leontief, Cobb-Douglas and CES production functions. On the demand side, the model distinguishes only one representative household and private consumption follows a LES, while public consumption is Cobb-Douglas.

Three comparative statics simulations are reported by Gelb [19]. The first assesses the impact effect of using the windfall to increase: a) public investment, b) public consumption, c) direct transfers to private households, and d) subsidies on domestic goods and services. The second set analyses domestic oil pricing policy by removing domestic petroleum price subsidies and making

[19] Dynamic simulations and optimization over a 20-year horizon are to be presented by Gelb in a second paper.

offsetting fiscal adjustments. The third set investigates policies which aim to neutralize two frequently undesired side-effects of oil booms: increases in the domestic price level relative to foreign prices, and the Dutch Disease.

Regarding the skewing of the Indonesian economy towards non-traded sectors, Gelb concludes that trade policy (e.g. export subsidies and a variety of controls) can affect the degree of real appreciation, but can only shift the burden of adjustment between non-oil tradeable sectors. Oil exporting countries then, should expect at least some of the non-oil traded sectors to lag behind in general economic growth during the phase of rising oil revenues and domestic spending.

The main feature of Dutch Disease Models is that they are based explicitly on international trade theory and provide a useful and interesting picture of what will happen to an economy in response to a boom in its natural resource sector. However, they are basically static models, and therefore, do not provide much insight into intertemporal questions.

The third, and perhaps most fundamental class of questions arises from the fact that the supply of most natural resources is finite. As was seen in section 2.1, an economy like the Mexican, with large reserves of an exhaustible resource, is faced with important choices concerning the rate at which the resource is depleted, and the size, composition and financing of its investment effort. As Devarajan op.cit. points out, with perfect capital markets, economic theory tells us, this question is largely independent of the rest of the economy; to the extent that extraction costs can be ignored a GE model is unnecessary [20]. However, since in most countries capital markets are imperfect, and extraction costs are not negligible, the resource depletion question is intimately linked with the country's savings and investment decisions, and a GE model is the appropriate tool. These questions are of an intertemporal nature and therefore are best treated in the context of Optimal-Depletion Models (ODM), where time plays a crucial role.

One of the most important examples of ODM is given by the work of Martin and van Wijnbergen (1986). They constructed a long-run optimal growth model of the Egyptian economy disaggregated into four sectors: traded, non-traded, oil, and gas, and where the objective function consists in maximizing the intertemporal utility of consumption. Their model is used to evaluate the rate at which oil and gas should be depleted, and to analyze three shadow prices: the effect of changes in the real exchange rate on optimal borrowing strategies; the accounting rate of interest or the social valuation of future goods in terms of current goods; and the shadow price of natural gas. One of the main conclusions of this study is that the static approach to shadow pricing that is standard in applied work, and the resulting use of a

[20] The original statement of this result is by Hotelling (1931). See also Solow (1974) and Devarajan and Fisher (1981).

relative shadow price structure that is constant over time, can be extremely misleading.

Martin and van Wijnbergen argue that a static approach is especially inappropriate when important structural changes are anticipated, and reductions in remittances and in revenues from oil are expected to take place as in both Egypt and Mexico. These factors were shown to have significant implications for the level and time pattern of the real exchange rate. This demonstrates, in the authors' view, the usefulness of an explicitly intertemporal optimization approach to the derivation of shadow prices.

Another example of ODM is the work by Blitzer and Eckaus (1986a) which constitutes the starting point of the model constructed here. This will be reviewed in the next chapter.

To sum up, ODM are normative in nature, that is, they have an explicit objective function. They are a powerful framework within which to discuss, simultaneously, a country's resource depletion, foreign borrowing, and investment strategies. Since the present work is also interested in these types of issues, the model to be constructed and applied in this thesis falls into this category.

Economy-wide Approaches:

The above three categories of models can also be broadly classified as either CGE or as optimizing models; which method is 'best' basically depends on three factors, namely: the economic or policy issues to which the researcher wants to give special attention; the demands that they make for data, time, and resources of expertise and computational capabilities; and the economic behaviour underlying the models [21]. Next, some of the main advantages and disadvantages of these two approaches are examined, beginning with CGE models [22].

The most distinguished feature of CGE models is that they solve for prices endogenously in both factor and product markets. In contrast to optimizing models, they are not based upon the central authority paradigm but take account of individual classes of consumers. CGE models are particularly strong in examining the effects of policy reforms such as trade liberalization by means of comparative statics. However, as Bell and Srinivassan (1984) explain, CGE models are rather weak in modelling long-run processes of development and change because of their recursive nature. In effect, all decisions in CGE models are made period by period and all agents use information available in the current period. In general terms then, in a multi-period CGE framework, there is no dependence of present actions on future states of the world.

[21] Blitzer and Eckaus, op.cit., comment that the choice of what model to choose is also affected by the scope and intensity of the energy-economy interactions. They say that more complicated methods (in terms of the level of disaggregation, the time periods considered, etc.) would be appropriate for, say, Mexico, with its large petroleum and industrial sectors than for say, Kenya, even if they had similar data bases.
[22] For reviews of these two methods, see Blitzer et al. (1975), Dervis et al. (1982), and Bell and Srinivassan (1984).

Using Manne's (1985) words, "dynamic CGE models deal with only one period at a time, neglecting the impact of subsequent changes in tastes, technologies or resource endowments". In a recursive CGE model, therefore, economic agents make myopic decisions about savings, investment allocations and international borrowing.

This drawback of CGE models is particularly restrictive for modelling energy issues because most questions regarding the relationship between natural resources and the macroeconomy require an intertemporal perspective. Moreover, the energy-economy aspects that this research wants to look at involve intertemporal trade-offs, for example, between more or less foreign borrowing and accelerated or slow growth in oil exploitation and exports. At the same time, as many of the adjustments to changes in energy policy occur with quite long lags, an energy-economy model should be able to deal explicitly with alternative time sequences and make at least medium-term projections.

In contrast to CGE models, an optimizing framework breaks away from recursiveness by encompassing sectorial interactions and intertemporal considerations that allow to solve models which are specified so as to cover many years. As shall be explained in section 5.3, the advance in non-linear programming algorithms enables the construction of non-recursive optimizing models that permit finite-time horizon efficiency, a result that lies beyond the reach of CGE models. It has to be said, on the other hand, that the long-run perspective in optimizing models is filled with uncertainties and involves only rough estimates of the future environment. This perspective, however, seems essential for the analysis of long-term development issues.

In addition, in contrast to earlier LP models, where the range of endogenous choice was very limited (e.g. consumption demands were price inelastic), numerical optimization methods are now capable of handling a sizable number of price-sensitive non-linear relationships, both in the objective function and in the constraints. This enables modellers to address intertemporal trade-offs in the proper non-recursive optimizing framework.

In summary, in formulating dynamic GE models, two distinct approaches can be employed: a recursive model that takes one period at a time (CGE), and a model optimized intertemporally (optimizing framework). Each approach has certain advantages and disadvantages. It can be said that economy-wide optimization models treat intertemporal issues in a more satisfactory manner but are unwieldy in analyzing price, tax, and subsidy questions. The CGE models, on the other hand, are better with the latter type of issues but are myopic in their intertemporal analysis. Yet, both types of models are general in scope and take energy-economy interactions fully into account.

In the following chapter a SAM version of the model will be formulated in order to compare it against some of the more representative GE models constructed for the case of Mexico.

CHAPTER IV.

A SAM FOR THE ANALYSIS OF ENERGY-ECONOMY INTERACTIONS IN MEXICO.

This chapter serves two purposes. The first is to review and compare the underlying structure and specification of three GE models for Mexico, within a SAM-type conceptual framework. The second objective is to formulate the one-period version of the model using the same SAM approach. The chapter is divided into two sections. Section 4.1 describes and compares three GE models constructed for Mexico in terms of (i) the classification of accounts; (ii) behavioural assumptions and characteristics; (iii) data base; and (iv) closure rules. Section 4.2 provides a description of the SAM accounts required for the purpose of the present study, and then compares these with the classification and behavioural specification adopted by the three GE models reviewed in the previous section.

4.1 SAM-Type Models for Mexico: Comparative [1].

Nowadays, there are a number of GE models for Mexico and some of them have been used to analyze energy issues. To our knowledge, the GE models carried out for Mexico in the last ten years are the following: Serra-Puche (1979), Sidaoui (1979), Reyes-Heroles (1982), Fischer et al.

[1] The historical development of economic data systems and the evolution of the SAM has been described by Stone (1977) and Pyatt (1987), while the structure and potential of a SAM framework has been laid out in Pyatt, Roe, and associates (1977), Pyatt and Round (eds.) (1985), and Pyatt (1988). This section is also based on Thorbecke (1985).

(1982), May-Kanosky (1983), Easterley (1985), de Urquijo (1985), Blitzer and Eckaus (1986a), Lustig et al. (1986), Levy (1987), and Baillet (1988). With the exception of Blitzer and Eckaus, who employed optimization techniques, the rest utilized the CGE framework.

Here only three of these GE models are reviewed, namely: Serra-Puche (1979) [2], Reyes-Heroles (1982), and Blitzer and Eckaus (1986a); (SP), (RH), and (B-E), hereafter, respectively. The reason for restricting attention to these studies is that the first two probably represent the best examples of CGE models developed for Mexico, while (B-E) not only differs from the rest in that it is based on an optimization approach, but as stated previously, it constitutes the starting point of the present model.

The analysis of these three economy-wide models is carried out within a SAM-type conceptual framework, it being now widely accepted that for each economic model there is a corresponding SAM [3]. In other words, models rely either implicitly or explicitly on a SAM-type approach and, therefore, a SAM provides the frame of reference for analyzing and comparing models. Briefly, a SAM is a square matrix that represents inter alia the union of two separate data schemes: national income

[2] It is important to say that the model of (SP) that is reviewed here is the original study which was implemented to analyze fiscal policies. However, this model has subsequently been transformed to examine some other issues including energy policy. See Kehoe and Serra Puche (1983).

[3] For any given SAM, however, there are several possible models. As Pyatt (1987, p.34) points out, "the choice of SAM restricts the choice of models, but it does not determine it uniquely".

accounts in matrix form and the Leontief I-O model of production. A SAM is always square since each economic agent has a row and a column registering his receipts and expenditures, respectively. This matrix provides a picture of the interdependence of the economy through the circular flows that make up the identities of national income accounting.

In a narrow sense, a SAM is a systematic data and classification system. In a broader sense, it can be used as an analytical framework, specifying, for a set of interconnected subsystems, the major relationships among variables within and between these subsystems (see Pyatt and Thorbecke, 1976) [4]. Hence, it is in this broader sense of a SAM that an attempt is made to bring out the major similarities and differences in the structure and specification of the three economy-wide models for Mexico. The comparative evaluation is presented in a synoptic way and in four steps. First, the classification of accounts of each model is described. Second, their behavioural rules and main characteristics are discussed. Third, the data base of the models is explained; and finally, the closure rules that fully determine each system are examined.

(1). Classification of Accounts.

Table 4.1 shows a simplified SAM that captures the basic disaggregation of accounts used by all three GE models.

[4] Only in a special (linear) case does the SAM as a data system become identical with the SAM as a conceptual framework or model. See Thorbecke, 1985.

Table 4.1
A SAM for Energy GE Models:
The Case of Mexico.

EXPENDITURES / RECEIPTS			FACTORS		INSTITUTIONS				PRODUCTION				ROW	
			Income to Labour	Income to Capital	Households	Government	Savings	Capital Formation	Non-Oil Activities	Oil and Gas Extraction	Domestic Commodities	Import Commodities	Rest of the World	TOTAL
			1	2	3	4	5	6	7	8	9	10	11	12
FACTORS	Income to Labour	1							Value added Payments to Labour	Value added Payments to Labour				Total Labour Income
	Income to Capital	2							Value added Payments to Capital					Non-Oil Capital Income
CURRENT ACCOUNTS	Households	3	All Wages Accrue to Households	Non-Oil Profits to Households		Government Transfers to Households							Remittance and other Incomes from abroad	Total Households Incomes
	Government	4		Non-Oil Profits to Government	Direct Taxes					All Oil Profits Accrue to Government	Indirect Taxes on Domestic Commodities	Indirect Taxes on Imports		Total Government Income
CAPITAL ACCOUNTS	Savings	5			Households Savings	Government Savings							Balance of Payments Current Deficit	Total Savings
	Capital Formation	6					Investment in Capital Stock							Total Capital Formation Receipts
PRODUCTION	Non-Oil Activities	7									Non-Oil Domestic Commodity Supply		Non-Oil Exports	Total Non-Oil Receipts
	Oiland Gas Extraction	8									Oil & Gas Domestic Commodity Supply		Oil & Gas Exports	Total Oil & Gas Receipts
	Domestic Commodities	9			Households Domestic Commodity Consumption	Government Domestic Commodity Consumption		Investment Expenditures on Domestic Commodities	Non-Oil Intermediate Commodity Demand	Oil & Gas Intermediate Commodity Demand				Total Domestic Commodity Demand
	Import Commodities	10			Households Import Commodity Consumption	Government Import Commodity Consumption		Investment Expenditures on Import Commodities	Non-Oil Import Commodity Demand	Oil & Gas Import Commodity Demand				Total Imports Commodity Demand
ROW	Rest of the World	11				Interest Payments Abroad	Change in Reserves					Total Imports		Total Payments Abroad
TOTAL		12	Total Labour Payments	Non-Oil Capital Payments	Total Household Expenditures	Total Government Expenditures	Total Investment	Total Capital Formation Expenditures	Total Non-Oil Costs of Production	Total Oil & Gas Costs of Production	Total Domestic Commodity Supply	Total Imports Commodity Supply	Total Receipts from Abroad	

This SAM presents a picture of the transactions within the Mexican economy (accounts 1 to 10), as well as with the rest of the world (ROW) (account 11), for a particular time period. Each account consists of a row (income) and a column (expenditure). Table 4.1 also presents a simple description of the relevant cells of the SAM.

The main differences between the three models in terms of classification of accounts within this SAM come from the following four modules: factors of production, households, domestic commodities and imports, and production activities. Factors of production can be broken down according to labour skills, type of capital, and other inputs. Households are basically classified according to socioeconomic criteria. Commodities can be split into specific or sectorial goods and services, while production activities are typically aggregated by sectors. Table 4.2 provides a comparative synopsis of the disaggregation of accounts for each of the four modules specified by the three SAM-type models constructed for Mexico.

As can be seen in Tables 4.2 to 4.5, there are various differences in terms of the choice of classification of the accounts and the level of disaggregation adopted by each model. This is not surprising if one considers the particular issues that each researcher wants to explore [5]. For example, the models of (SP) and (RH) try to

[5] The major policy means and experimentation of each model are described in Table 4.6 of next sub-section.

Table 4.2
SAM-Type Models for Mexico: Comparative.
Classification of Accounts.

	Serra Puche (1979):	Reyes Heroles (1982):	Blitzer and Eckaus (1986):
Factors of Production.	There are 4 factors of production in the economy: (1) Rural labour. (2) Urban labour. (3) Capital stock which is assumed to be homogeneous and freely mobile across sectors. (4) Intermediate inputs.	Factors of production are divided into: (1) Labour. (2) Different capital stocks for each of the 19 production sectors. Capital cannot be shifted out of a sector once it is installed. (3) Intermediate inputs. (4) Non-competitive imports.	Value added is generated by: (1) Skilled labour, and (2) Sector-specific capital stocks for each of the 9 production activities. In addition, the production structure employs two more factors: (3) Intermediate inputs, and (4) Non-competitive imports.
Household Groups.	Capital and labour are owned by 10 groups of domestic consumers, differentiated according to their average income. They are divided into 5 different income brackets in rural and urban areas (see Table 4.3).	From the above total income accruing to 12 household groups is generated. Households are defined according to their income earnings per economic stratum (see Table 4.3).	The existence of a representative consumer with initial endowments of capital and labour is assumed.
Domestic Commodities and Imports.	Domestic commodities are divided into 15 categories shown in Table 4.4. A particular feature of this model is that consumers demand specific goods. For example, they do not demand agriculture as such, but goods that use its output such as bread, etc. Imports, on the other hand, are non-competitive and compose a homogeneous good.	There are 8 domestic goods and services which appear in Table 4.4. Construction does not appear in that Table because it is delivered entirely to investment, so that it is not available for consumption. Finally, there is a single category of imports: non-competitive.	This household consumes 7 goods and services (see Table 4.4). The consumption index excludes construction and government services because the former is delivered entirely to investment, while government services are delivered entirely to government consumption. On the other hand, two types of imports are disaggregated: competitive and non-competitive.
Production Activities.	Production activities are broken down into 14 sectors after consolidating a 72 sector I-O matrix (see Table 4.5). Since there are 15 commodities and 14 production sectors a conversion matrix is used to transform the final demand for each good into implicit demands for activities, including markups generated in the commercialization process. For example, when consumers acquire bread, they implicitly demand the output of several sectors, namely: agriculture, food products, and commerce.	The economy is divided into 19 production activities which follows the same disaggregation of domestic commodities, with the exception of construction which is included as a producing sector (see Table 4.5). A special feature of this model is the dualistic nature of the classification of some production sectors. Specifically, modern and traditional activities are identified in agriculture, commerce and services.	There are 9 producing activities in the economy. As can be seen in Table 4.5, there is a distinction between oil and gas and petroleum products. Yet, refining and petrochemicals are not disaggregated. Also, commerce, communications and services are aggregated into a single sector, as are mining and manufacturing activities.

Table 4.3
Classification of Household Groups
in SAM-Type Models for Mexico.

Household Group	Serra Puche (1979)[1]	Reyes Heroles (1982)[2]
1	Urban poor (0-1800)	80.45
2	Rural poor (0-1800)	100.25
3	Urban low income (1801-3150)	123.28
4	Rural low income (1801-3150)	139.55
5	Urban low to middle income (3151-5785)	199.88
6	Rural low to middle income (3151-5785)	245.68
7	Urban middle income (578-13400)	318.88
8	Rural middle income (578-13400)	417.99
9	Urban upper income (13401 and up)	471.46
10	Rural upper income (13401 and up)	586.03
11		775.46
12		1695.03

[1] Pesos per month net income. Figures for 1977.
[2] Pesos per month per capita income. Figures for 1970.

Table 4.4
Classification of Domestic Commodities
in SAM-Type Models for Mexico.

Serra Puche (1979)	Reyes Heroles (1982)	Blitzer and Eckaus (1986)
1) Bread & cereals.	1) Modern agricult.	1) Agricult, forestry, dairy & fisheries.
2) Milk & eggs.	2) Traditional agr.	2) Mining & Manufact.
3) Other groceries.	3) Livestock, fishing & forestry.	3) Transport.
4) Fruits & veget.	4) Mining.	4) Commerce, Communications & Services.
5) Meat.	5) Oil & gas.	5) Oil & gas.
6) Fish.	6) Food prod.	6) Refining & Petroch.
7) Beverages.	7) Textiles.	7)Electricity
8) Clothing.	8) Wood, paper, etc.	
9) Furniture.	9) Chemical & petrochemical prod.	
10) Elect. prod.	10) Non-metalic prod.	
11) Medical prod.	11) Basic metals.	
12) Transportation.	12) Machinery & other manufactures.	
13) Educational articles.	13) Electricity.	
14) Articles for personal care.	14) Transport and Communications.	
15) Services.	15) Modern Commerce.	
	16) Traditional Comm.	
	17) Modern Services.	
	18) Traditional Serv.	

Table 4.5
Classification of Production Activities
in SAM-Type Models for Mexico.

Serra Puche (1979)	Reyes Heroles (1982)	Blitzer and Eckaus (1986)
1) Agriculture.	1) Modern Agric.	1) Agriculture, forestry, dairy & fisheries.
2) Mining.	2) Traditional Agr.	2) Mining & Manufact.
3) Petroleum & petrochem.	3) Livestock, etc.	3) Transport.
4) Food prod.	4) Mining.	4) Commerce, Communic., & Services.
5) Textiles.	5) Oil & gas.	5) Oil & gas.
6) Wood prod.	6) Food products.	6) Refining & petrochem.
7) Chemical prod.	7) Textiles.	7) Electricity.
8) Nonmetal prod.	8) Wood, paper, etc.	8) Construction
9) Machinery & automobiles.	9) Chemical & petro-chemical products.	9) Government Services.
10) Electricity.	10) Nonmetalic prod.	
11) Commerce.	11) Basic metals.	
12) Transport.	12) Machinery & other manufactures.	
13) Services.	13) Construction.	
14) Construction.	14) Electricity.	
	15) Communications & Transportation.	
	16) Modern Commerce.	
	17) Traditional Comm.	
	18) Modern Services.	
	19) Traditional Serv.	

analyze income distribution issues and, consequently, household groups are disaggregated into various categories (see Table 4.3), whereas the model of (B-E) does not deal with these issues and, therefore, no attempt is made to distinguish between consumer groups. Similarly, the classification of domestic commodities shown in Table 4.4 and of production activities (Table 4.5), reflect the respective purposes of the studies [6].

(2). Behavioural Rules and Characteristics.

The next step in the comparative evaluation of the three models is undertaken on the basis of the major interdependent links among the accounts shown in the simplified SAM of Table 4.1. The first part of the analysis abstracts, for the sake of simplicity, from the ROW and capital accounts. In short, the feedback system (loop) goes from production activities which generate a flow of value added which accrues to factors of production. The resulting factorial income distribution provides the major source of income for institutions including households. When transfers (taking into account taxes and subsidies) are added, disposable income is determined, which, in turn, is spent on a variety of commodities and services which are supplied by the production activities.

In addition, a number of characteristics and criteria are used to capture the essence of the models, namely

---

[6] Section 4.2 compares the classification of accounts chosen for the present model, against the classification followed by the three GE models reviewed above.

[7]: (a) price formation, (b) nature of production function, (c) degree of substitution among primary inputs and employment determination, (d) nature of consumption function, (e) government expenditure determination, (f) investment expenditure determination, (g) treatment of foreign sector, (h) major policy means and experimentation, (i) type of economy-wide model, (j) treatment of static and dynamic forces, and (k) software used to solve the model. Table 4.6 provides a comparative synopsis of the three models according to the above links and characteristics.

(3). Data Base.

Table 4.7 describes in a synoptic way the main information sources employed to construct the data base of each study, as well as some of the estimations and assumptions needed to calculate the various parameters of the models. The analysis is divided into five modules: production structure, consumer-demand structure, government activity, primary inputs, and foreign sector.

As can be seen in this Table, only (RH) explicitly uses a SAM-type information system, whereas the other two studies rely implicitly on a SAM data framework. On the other hand, the three economy-wide models employed the 1970 I-O Table as the basis of their data, although (SP) updated it to 1977 through RAS. Section 4.2 will describe

---

[7] This type of analysis is based on Thorbecke (1985, Table 10.9, pp. 234-39).

Table 4.6
SAM Type Models for Mexico: Comparative
Behavioural Rules and Characteristics.

	Serra Puche (1979):	Reyes Heroles (1982):	Blitzer and Eckaus (1986):
Production Activities. **Factorial Income Distribution (Value Added).**	At first, CES production functions are specified to generate value added from the two types of labour and capital. However, since the substitution parameters are assumed to be one in all sectors, this leads to a Cobb-Douglas technology for all production activities.	Value added from capital and labour is determined through constant-returns C-D production functions in all sectors.	The demand for capital and labour is determined using fixed capital and labour output ratios. However, 5 of its 9 production activities can use up to seven alternative technologies which require different amounts of inputs. These vectors and their linear combinations approximate the isoquant for each sector.
Factorial Income Distribution Household Expenditures on Commodities and Final Demand.	Prior to production, each of the 10 household groups owns capital and labour that, when evaluated at market prices, produce the group's income. The consumer groups are assumed to maximize their utility function of the C-D form subject to their respective income constraint, which includes transfers from the government and excludes tax payments and savings. Thus, demand responds to changes in commodity prices and to factor prices. The sum of the individual demands over all consumers leads to market demand functions. The other components of final demand are determined as follows: a) Government maximizes a Leontief utility function and is constrained by its income (tax revenue plus gov's capital endowment) and endowment of bonds (capital tomorrow). b) Investment is driven by savings. c) Exports are derived through fixed coefficients, and imports are strictly exogenous.	Disposable income by household class is derived after deducting savings and tax payments, and allowing for transfers and subsidies. Private consumption is then estimated through a standard LES. Consumers, thus, maximize their utility value of a basket of 18 goods subject to their respective disposable income. Regarding the other components of final demand: a) Government expenditures is exogenous. b) Exports are determined exogenously. c) Investment adjusts to savings.	The utility of consumption of each good in each year covered by the model is determined through three sets of equations that approximate an ELES: the first computes total consumption of the good; the second estimates the associated level of discounted utility; and the third stipulates the convexity constraints on individual weights. The other components of final demand are determined as follows: a) Government expenditures is an exogenous variable. b) Investment is calculated endogenously using fixed coefficients. c) All exports are exogenous, except oil and gas.
Household Expenditures on Commodities and Final Demand. **Production Activities.**	As indicated above, C-D production functions generate value-added from capital and labour. In addition, the production activities employ intermediate inputs, which are calculated through a fixed-coefficient Leontief system. Finally, production activities per sector combine in a two-level Leontief system, intermediate inputs and value added.	As indicated previously, constant-returns C-D production functions determine value added from capital and labour. Intermediate inputs and non-competitive imports, on the other hand, are employed by the production technology in a fixed-coefficient Leontief system.	As seen above, the amounts of each of the four types of inputs used in the production of each sector, is calculated on the basis of fixed coefficients. Yet, some substitution is allowed through choice among 7 alternative technologies with different factor proportions during each time period.

Price Formation.	Endogenous price determination. The model brings together demand and production decisions to determine equilibrium prices, equilibrium activity levels, and equilibrium tax revenues. In equilibrium, no activity makes profits and demand equals supply in every sector. Consumers maximize their utility and producers maximize their profits. Wages adjust so as to clear the labour market. Prices are solved iteratively.	Endogenous price determination, with the exception of the wage rate, which is not determined by the system, but by some social rule. Fixing the wage rate implies surplus labour in modern activities, whereas traditional sectors face underemployment. Consumers maximize their utility and producers maximize their profits. Product prices are determined so as to clear markets. Prices are solved iteratively.	Input and output prices are endogenously determined. During each time period, the model allocates resources among sectors to maximize the value of the objective function subject to several constraints. Simultaneously, price determined substitution for each endogenous category of final demand is chosen according to the maximand.
Nature of Production Function.	Production technology combines a Leontief system for intermediate inputs and value added, with a C-D technology that generates value-added from the 3 primary factors.	Constant returns C-D production functions generate value added from labour and capital, and Leontief systems determine the demands for both intermediate and non-competitive imports.	Five of the nine goods can be produced using up to seven alternative technologies which require different amounts of inputs on the basis of fixed coefficients. Sectorial gross output is then calculated as the sum of the output produced by each of the potential technologies available for that sector.
Substitution Among Primary Inputs; Employment Determination.	Unitary elasticity of substitution between the two types of labour and capital. Employment of rural and urban labour is determined through the operation of the labour markets equating labour supply and demand. This leads to full employment of both labour groups.	Unitary elasticity of substitution between labour and capital. As stated before, fixing the wage rate implies excess supply of labour in modern activities, while traditional sectors face underemployment. This causes migration which is modelled as a function of wage differentials. Traditional commerce and service sectors get non-agriculture underemployment.	Substitution is possible between inputs through choice among technologies with different input proportions based on endogenous factor and goods prices. Employment is determined along neoclassical lines by equating exogenously projected skilled labour supply with skilled labour demand. There is then, full employment of skilled labour.
Nature of Consumption Function.	Private consumers maximize a C-D utility function.	Private consumption is determined by a standard LES.	An Extended Linear Expenditure System (ELES) approximated by three linear equations is adopted as consumption function.
Government Expenditures	Government maximizes a Leontief utility function.	Exogenous.	Exogenous.
Investment Expenditures.	Investment expenditures adjust to savings.	Investment adjusts to savings.	Endogenously determined. Investment then determines the capital stocks available for production during the optimizing horizon.

Foreign Sector.	All imports are non-competitive and compose a homogeneous good. They are determined exogenously, while exports are derived through fixed coefficients. Hence, trade deficit is exogenous which does not allow for the analysis of any external disequilibrium of the economy.	All imports are non-competitive and are derived through fixed coefficients. Exports are calculated exogenously. Thus, this specification of the foreign sector does not allow for an endogenous determination of the trade deficit.	Competitive imports are determined endogenously, but are allowed only in manufacturing, agriculture, and refined products. Non-competitive imports are calculated through fixed coefficients which relate them to gross output and investment levels. With the exception of oil and gas exports, the remaining exports are given exogenously. The model also calculates foreign borrowing and repayment costs.
Major Policy Means and Policy Experimentation.	The original model is devoted to the analysis of tax incidence. It examines the impact on income distribution and resource allocation of the 1980 Mexican VAT Some major conclusions are: a) Resource allocation moved in favour of the target sectors (agriculture and food stuffs). b) Income distribution improved reducing the differentials between urban and rural groups. The model has also been used to analyze unemployment, energy, commerce and protection policies.	The model analyzes the direction and magnitude of the effects of short-run macroeconomic policies on income distribution and welfare. It also studies the relationship between growth and income distribution. Major conclusions of policy experimentation are: a) Income distribution and welfare are very sensitive to short-run macro policies. b) Contraccionists policies reduce welfare of the poorest families and deteriorate income distribution. c) Given the population rate of growth, a 7 percent GDP growth per year is needed to avoid a deterioration of income distribution and welfare of the poorest families.	The objectives of the model are twofold: first, is to examine the effects of exogenous changes in world oil prices and the cost of foreign borrowing on economic growth The main conclusion in this respect is that even with large oil reserves and a productive economy, conditions may be imposed by financial institutions which simply cannot be met quickly without changing some behavioural relations significantly. The second objective was methodological, namely, to explore the potential flexibility and practicality of an optimizing model as a tool for general equilibrium modelling of energy and development interactions.
Type of Economy-Wide Model.	Computable General Equilibrium Model (CGE).	CGE.	Optimizing Linear Programming General Equilibrium Model.
Static-Dynamic.	The model is essentially comparative-static.	The model is essentially comparative-static.	The model is dynamic and covers the 1977-2005 period divided into equal intervals of four-years length.
Algorithm Used.	The model is solved numerically by using a modified version of Scarf's algorithm for computing fixed points. For the simplicial subdivision of the simplex, it employs Merrill's method.	Not specified.	The algorithm used follows Dulloy and Hazell piece-wise approximations method (see section 5.3).

Table 4.6
SAM Type Models for Mexico: Comparative
Behavioural Rules and Characteristics.

	Serra Puche (1979):	Reyes Heroles (1982):	Blitzer and Eckaus (1986):
Production Activities. **Factorial Income Distribution (Value Added).**	At first, CES production functions are specified to generate value added from the two types of labour and capital. However, since the substitution parameters are assumed to be one in all sectors, this leads to a Cobb-Douglas technology for all production activities.	Value added from capital and labour is determined through constant-returns C-D production functions in all sectors.	The demand for capital and labour is determined using fixed capital and labour output ratios. However, 5 of its 9 production activities can use up to seven alternative technologies which require different amounts of inputs. These vectors and their linear combinations approximate the isoquant for each sector.
Factorial Income Distribution **Household Expenditures on Commodities and Final Demand.**	Prior to production, each of the 10 household groups owns capital and labour that, when evaluated at market prices, produce the group's income. The consumer groups are assumed to maximize their utility function of the C-D form subject to their respective income constraint, which includes transfers from the government and excludes tax payments and savings. Thus, demand responds to changes in commodity prices and to factor prices. The sum of the individual demands over all consumers leads to market demand functions. The other components of final demand are determined as follows: a) Government maximizes a Leontief utility function and is constrained by its income (tax revenue plus gov's capital endowment) and endowment of bonds (capital tomorrow). b) Investment is driven by savings. c) Exports are derived through fixed coefficients, and imports are strictly exogenous.	Disposable income by household class is derived after deducting savings and tax payments, and allowing for transfers and subsidies. Private consumption is then estimated through a standard LES. Consumers, thus, maximize their utility value of a basket of 18 goods subject to their respective disposable income. Regarding the other components of final demand: a) Government expenditures is exogenous. b) Exports are determined exogenously. c) Investment adjusts to savings.	The utility of consumption of each good in each year covered by the model is determined through three sets of equations that approximate an ELES: the first computes total consumption of the good; the second estimates the associated level of discounted utility; and the third stipulates the convexity constraints on individual weights. The other components of final demand are determined as follows: a) Government expenditures is an exogenous variable. b) Investment is calculated endogenously using fixed coefficients. c) All exports are exogenous, except oil and gas.
Household Expenditures on Commodities and Final Demand. **Production Activities.**	As indicated above, C-D production functions generate value-added from capital and labour. In addition, the production activities employ intermediate inputs, which are calculated through a fixed-coefficient Leontief system. Finally, production activities per sector combine in a two-level Leontief system, intermediate inputs and value added.	As indicated previously, constant-returns C-D production functions determine value added from capital and labour. Intermediate inputs and non-competitive imports, on the other hand, are employed by the production technology in a fixed-coefficient Leontief system.	As seen above, the amounts of each of the four types of inputs used in the production of each sector, is calculated on the basis of fixed coefficients. Yet, some substitution is allowed through choice among 7 alternative technologies with different factor proportions during each time period.

Price Formation.	Endogenous price determination. The model brings together demand and production decisions to determine equilibrium prices, equilibrium activity levels, and equilibrium tax revenues. In equilibrium, no activity makes profits and demand equals supply in every sector. Consumers maximize their utility and producers maximize their profits. Wages adjust so as to clear the labour market. Prices are solved iteratively.	Endogenous price determination, with the exception of the wage rate, which is not determined by the system, but by some social rule. Fixing the wage rate implies surplus labour in modern activities, whereas traditional sectors face underemployment. Consumers maximize their utility and producers maximize their profits. Product prices are determined so as to clear markets. Prices are solved iteratively.	Input and output prices are endogenously determined. During each time period, the model allocates resources among sectors to maximize the value of the objective function subject to several constraints. Simultaneously, price determined substitution for each endogenous category of final demand is chosen according to the maximand.
Nature of Production Function.	Production technology combines a Leontief system for intermediate inputs and value added, with a C-D technology that generates value-added from the 3 primary factors.	Constant returns C-D production functions generate value added from labour and capital, and Leontief systems determine the demands for both intermediate and non-competitive imports.	Five of the nine goods can be produced using up to seven alternative technologies which require different amounts of inputs on the basis of fixed coefficients. Sectorial gross output is then calculated as the sum of the output produced by each of the potential technologies available for that sector.
Substitution Among Primary Inputs; Employment Determination.	Unitary elasticity of substitution between the two types of labour and capital. Employment of rural and urban labour is determined through the operation of the labour markets equating labour supply and demand. This leads to full employment of both labour groups.	Unitary elasticity of substitution between labour and capital. As stated before, fixing the wage rate implies excess supply of labour in modern activities, while traditional sectors face underemployment. This causes migration which is modelled as a function of wage differentials. Traditional commerce and service sectors get non-agriculture underemployment.	Substitution is possible between inputs through choice among technologies with different input proportions based on endogenous factor and goods prices. Employment is determined along neoclassical lines by equating exogenously projected skilled labour supply with skilled labour demand. There is then, full employment of skilled labour.
Nature of Consumption Function.	Private consumers maximize a C-D utility function.	Private consumption is determined by a standard LES.	An Extended Linear Expenditure System (ELES) approximated by three linear equations is adopted as consumption function.
Government Expenditures	Government maximizes a Leontief utility function.	Exogenous.	Exogenous.
Investment Expenditures.	Investment expenditures adjust to savings.	Investment adjusts to savings.	Endogenously determined. Investment then determines the capital stocks available for production during the optimizing horizon.

Foreign Sector.	All imports are non-competitive and compose a homogeneous good. They are determined exogenously, while exports are derived through fixed coefficients. Hence, trade deficit is exogenous which does not allow for the analysis of any external disequilibrium of the economy.	All imports are non-competitive and are derived through fixed coefficients. Exports are calculated exogenously. Thus, this specification of the foreign sector does not allow for an endogenous determination of the trade deficit.	Competitive imports are determined endogenously, but are allowed only in manufacturing, agriculture, and refined products. Non-competitive imports are calculated through fixed coefficients which relate them to gross output and investment levels. With the exception of oil and gas exports, the remaining exports are given exogenously. The model also calculates foreign borrowing and repayment costs.
Major Policy Means and Policy Experimentation.	The original model is devoted to the analysis of tax incidence. It examines the impact on income distribution and resource allocation of the 1980 Mexican VAT Some major conclusions are: a) Resource allocation moved in favour of the target sectors (agriculture and food stuffs). b) Income distribution improved reducing the differentials between urban and rural groups. The model has also been used to analyze unemployment, energy, commerce and protection policies.	The model analyzes the direction and magnitude of the effects of short-run macroeconomic policies on income distribution and welfare. It also studies the relationship between growth and income distribution. Major conclusions of policy experimentation are: a) Income distribution and welfare are very sensitive to short-run macro policies. b) Contraccionists policies reduce welfare of the poorest families and deteriorate income distribution. c) Given the population rate of growth, a 7 percent GDP growth per year is needed to avoid a deterioration of income distribution and welfare of the poorest families.	The objectives of the model are twofold: first, is to examine the effects of exogenous changes in world oil prices and the cost of foreign borrowing on economic growth The main conclusion in this respect is that even with large oil reserves and a productive economy, conditions may be imposed by financial institutions which simply cannot be met quickly without changing some behavioural relations significantly. The second objective was methodological, namely, to explore the potential flexibility and practicality of an optimizing model as a tool for general equilibrium modelling of energy and development interactions.
Type of Economy-Wide Model.	Computable General Equilibrium Model (CGE).	CGE.	Optimizing Linear Programming General Equilibrium Model.
Static-Dynamic.	The model is essentially comparative-static.	The model is essentially comparative-static.	The model is dynamic and covers the 1977-2005 period divided into equal intervals of four-years length.
Algorithm Used.	The model is solved numerically by using a modified version of Scarf's algorithm for computing fixed points. For the simplicial subdivision of the simplex, it employs Merrill's method.	Not specified.	The algorithm used follows Dulloy and Hazell piece-wise approximations method (see section 5.3).

Table 4.7
SAM-Type Models for Mexico: Comparative
Data Base.

	Serra Puche (1979):	Reyes Heroles (1982):	Blitzer and Eckaus (198):
Data Framework.	Input-Output Table plus some other estimates.	SAM plus some other estimates.	I-O Table and some other estimates.
Base Year.	1977.	1970.	1977.
Production Structure.	The production side of the economy is integrated using the I-O matrix for 1970 and updated to 1977 through the row and column sum (RAS) method. The technical coefficients for intermediate demands are derived from the I-O table. The value added parameters of the CES technology are computed under the assumption of profit maximization. The substitution parameters are assumed to be one in all sectors. The distribution parameters are derived from the first order conditions by assuming all prices to be equal to one: their equilibrium values in the benchmark situation. The efficiency parameter is subject to calibration to ensure that the model's total production per sector is identical to the actual values.	The production structure of the economy is based on the 1970 SAM. The traditional production sectors, are disaggregated using some other sources: 1970 Agricultural, Commercial and Services Census. The intermediate and non-competitive imports coefficients are directly obtained from the SAM. The constant-shift parameter of the C-D are calculated using own estimates, assuming neutral technological change "a la Hicks". Input-share parameters are derived assuming that value-added from capital and labour is the result of the long-run equilibrium. Constant-returns to scale then implies that these parameters are given by the share of labour and capital in value-added for each sector, shown in the SAM.	The data base for the sectorial production is based on the 1977 I-O matrix constructed by Serra Puche. The technical coefficients for calculating the demands for intermediate inputs and non-competitive imports are directly obtainable from the I-O matrix. The fixed coefficient relating non-competitive import demand per unit of investment is estimated from the capital matrix. No information is specified about the estimation of capital-output and labour-output ratios required to calculate value-added.
Consumer-Demand Structure.	The consumer-demand side of the economy is obtained from the household survey for 1977. The demand parameters of the C-D utility function are obtained from the shares of expenditure per good by each consumer group, and adjusted so as to have the market demands equal to the final private consumption column in the I-O matrix. The initial endowments of the consumer groups are also adjusted to match value-added in the A matrix.	The main information sources used here are the 1970 population census and the 1968 household survey. Log-linear approximation was used to interpolate income strata per household group from the census. The author carried out econometric estimates to derive the sectorial parameters of the LES.	The 1977 household survey is used to estimate the parameters of the ELES. The discount rate of consumption is assumed to be 0.1. In the approximation of the ELES through the piece-wise method, 10 segments for each non-lineal approximation are used. The parameters are adjusted in each period to reflect population growth and the effect of time discounting.
Government Activity.	The information of the government activity is taken from the I-O matrix, including the value added parameters. The tax for each good is a weighted average of effective rates, which are computed by finding the turnover	Government data is taken from the SAM. However, several modifications are made to calculate net indirect taxes, direct taxes, subsidies and transfers. These are based on Banco de Mexico's and other official statistics, as well as	Government expenditure is forecast on the basis of a growth rate applied to the initial vector of government consumption obtained from the I-O Table. A real annual growth rate of about 8 percent is assumed for

	in the I-O matrix. The initial endowments of the consumer groups are also adjusted to match value-added in the A matrix.		population growth and the effect of time discounting.
Government Activity.	The information of the government activity is taken from the I-O matrix, including the value added parameters. The tax for each good is a weighted average of effective rates, which are computed by finding the turnover tax and the special tax rates that yield the actual government revenue in 1977. In this case, neutrality of tax evasion within the sector is assumed. Also, income tax evasion is assumed to be neutral across consumers and independent of the income sources. Tariff and export taxes are computed simply by finding the rates that yield the actual revenues, since imports are a homogeneous good and all exports face the same tax rate.	Government data is taken from the SAM. However, several modifications are made to calculate net indirect taxes, direct taxes, subsidies and transfers. These are based on Banco de Mexico's and other official statistics, as well as from data of some private studies and own estimates carried out by the author.	Government expenditure is forecast on the basis of a growth rate applied to the initial vector of government consumption obtained from the I-O Table. A real annual growth rate of about 8 percent is assumed for the 1981-2001 period.
Primary Inputs.	Capital is defined in a residual manner and it actually includes all those inputs within value-added that are no labour or indirect taxes. These figures are obtained from the I-O Table. Regarding the exogenously projected labour supplies, no indication is given about their data source.	Initial endowments of capital stocks per sector are estimated on the basis of capital-output ratios calculated from historical data published by Banco de Mexico for the 1950-67 period. The disaggregation of the capital stocks in modern and traditional activities is based on the actual distribution of net capital. The main sources of labour statistics are the 1970 Population Census and the SAM itself.	Initial endowments of capital stocks are calculated from capital-output ratios. There is no indication of the sources used to compute these ratios, the depreciation rates, or the exogenously projected labour supplies for each time period.
Foreign Sector.	The foreign sector data only requires the trade deficit for the base year, which is consistent with the rest of the variables. This is obtained from the A Table.	Exports and non-competitive imports are computed directly from the SAM. Foreign remittances and other incomes from abroad are assumed to be the difference between family transfers given and family transfers obtained which are shown in the 1968 household survey.	Apart form the initial vectors of exports and imports appearing in the I-O table, no explanation is given about the sources used to derive exogenous exports, price of both types of imports and exports, etc. Foreign borrowing and debt service equations use 10 segments for each linear approximation. Oil and gas extraction equations employ 6 linear approximations.

some of the improvements in terms of information that can now be made as a result of more recent developments.

(4). Closure Rules.

The final comparison of the three GE models is carried out in terms of the set of equations required to fully determine each system. This set of equations is known as closure rules, and will be discussed in some detail in part (c) below. But first it is important to explain why macroclosures are necessary.

The presentation of a model in a SAM framework requires that models be presented as a set of equations that describe the ways in which prices and transaction values are determined (see Pyatt, 1987 and 1988). That is, algebraic equations are expressed as functions of incomes and prices which represent what is now called the Transaction Value (TV) part of a model. This TV approach contrasts with the normal procedure in economics of presenting models as a set of equations that show the means by which prices and quantities are determined [8].

Thus, the SAM accounting identities shown in Table 4.1 yield the TV part of the model, which is formed by two sets of equations: column summation equations (supply side), and row summation equations (demand side). These

[8] Translating a model expressed in TV form into the standard format of prices and quantities is simple. No logical distinction between the two formulations exists, but choosing the TV form has advantages for modelling in four main areas (Drud et al., 1986 p.113): 1) The choice of details in relation to the issues, on the one hand, and the availability of data, on the other. 2) Making the best use of available data. 3) Understanding model behaviour, and 4) calibration and solution.

two sets of equations are basic to model structure and shall be discussed next.

(a) Column summation equations.

Column summation equations are divided into relative-price equations and non-price equations (Drud et al., 1986):

(i) Relative price equations:

These equations refer to the column summation of the activity and commodity accounts in Table 4.1. The basic conceptualization is explained by Pyatt (1987, p.23) as follows: " if total costs must equal total revenue, then price, or average revenue, must equal average cost, which depends, of course, on prices. Hence prices are interdependent and the column summation equations for activities and commodities describe this interdependence" This yields a linear homogeneous equation (1) [9], which represents the first of the three sets of equations that allow to solve any macro model.

(1) $p = p(y; p,f,e)$

The set of equations (1) shows that commodity and activity prices depend not only on each other, p, but also on factor prices, f, the price of foreign exchange, e, and, in the most general case, on the income levels of particular activities, y, or scale of production. These equations also allow as a special case the fact that the price level is independent of the scale of production,

[9] If input prices double and the scale of production stays constant, then output prices will double.

provided that factor prices and the exchange rate are given [10].

(ii) Non-price equations:

The remaining column summation equations are known as non-price equations and they are, essentially, statements of adding-up conditions which need to be satisfied if all income is to be exactly accounted for as an outlay. An example of this can be seen in the factor accounts of Table 4.1. Assuming no discrimination in the factor markets, then the allocation of the income of any one input will be in proportion to the ownership of that factor by the different institutions. Hence, column summation in this case implies that the total income for each factor is allocated in proportions which add to 100 percent. In a similar way, if a column contains a residual as an element, then total outlay must be equal to total income. In both cases no new restrictions or information on the system is implied.

In general, therefore, it can be said that all column summation balancing conditions are satisfied if and only if equations (1) are satisfied. Column summation equations of the SAM provide a check of adding-up conditions within the model, and otherwise, generate {p} supply equations, showing how commodity prices are determined so as to clear markets.

---

[10] This special case known as fix-price, would arise if production technology was characterized by constant returns to scale and in the absence of any quantity restrictions on imports, for example, which would otherwise tend to rise prices as the scale of activity expands.

(b) Row summation equations.

Accounting consistency by columns is complemented by accounting consistency by rows. Row summation is given by the set of equations (2):

$$(2) \quad y = n + x$$

where n and x are the column vectors of the row sums of endogenous and exogenous demands, respectively. Equations (2) represent the second set of model equations. They correspond to the demand side of the system insofar as they explain how the total income in each account, y, is derived from endogenous and exogenous demands. More specifically, the endogenous sources of income, n, will capture the interdependence of incomes in the different accounts as a result of the circular flow of income [11].

It is important to notice, however, that if all columns of the SAM satisfy accounting consistency then, as a mathematical necessity, one of the rows will do so also, provided that all others do. Consequently, one of the equations (2) is linearly dependent on the others given the column summation equations. Hence, accounting consistency by rows provides {y}-1 linearly independent restrictions. Taken together then, column and row summation equations define {p} + {y}-1 linearly independent restrictions.

[11] These equations show the interdependence of the economy and, for example, its dualities and the way in which production structure and income distribution are interconnected. See Pyatt, 1988.

Since the variables of the system are: f, factor prices; p, activity and commodity prices; y, incomes; and one exchange rate, e; it follows that {f}+2 degrees of freedom in the form of closure rules must be taken up to close a model.

(c) Closure Rules:

In the literature of applied GE models, the term closure rule has been used to refer to how an economy-wide model achieves balance between savings and investment [12]. This is not entirely correct since the term is not necessarily restricted to the closure of the savings-investment account. As Pyatt (1987) explains, there is a wide range of choices available for closure rules. Typically, they specify how each factor market and the capital account of the economy are closed. Therefore, macroclosures are really better seen as the third set of equations that define macroeconomic equilibrium of any model [13].

It has already been noted that column summation implies {p} linear homogeneous restrictions, so given that a system has {f}+{p}+1 prices, then {f}+1 degrees of freedom remain in the determination of prices [14]. If exactly f+1 price restrictions exist (in relative or absolute terms), then the system of prices will be

---

[12] See, for example, Taylor, 1979, and Dervis et al., 1982, chapters 5 and 12.

[13] As Pyatt (1987) argues, since every model has its own SAM framework, it follows that every model has this three part structure: column and row summation equations (TV part), and closure rules.

[14] Recall that f+2 degrees of freedom remain in the determination of both prices and incomes. Of these, f+1 correspond to prices.

exactly determined in the model. If equations (1) are of the form: p = p(p,f,e) then, as stated before, we have a fix-price model, so that for fixed values of f and e, equations (1) yield prices, p, which are independent of the scale of production, y [15]. Otherwise, as seen in the original equation (1), prices are a function of incomes, and this case is known as flex-price model. In any event, at least one price must be set exogenously because all other equations in the system are homogeneous of degree one in prices and incomes [16]. In the case that closure rules in the form of price restrictions were still insufficient to close the system, the remaining macroclosures will restrict quantities, so as to complete the specification of an exactly determined system.

In the light of the above discussion, Table 4.8 presents a comparative synopsis of the closure rules specified by the three GE models for Mexico which balance each factor market and the savings-investment accounts of the SAM shown in Table 4.1.

As can be seen in Table 4.8, although the three SAM-type models reviewed are of the flex-price type, there are some important differences in the choice of closure rules, particularly regarding the way in which the savings-investment account is balanced. In both (SP) and (RH) CGE models the current account deficit is fixed, so

[15] For an analysis of further implications of the fix-price case, see Pyatt, op.cit.

[16] Usually this closure rule takes the form of setting the exchange rate or any other price or set of prices as numeraire for the system as a whole.

Table 4.8
SAM-Type Models for Mexico: Comparative
Closure Rules.

	Serra Puche (1979):	Reyes Heroles (1982):	Blitzer and Eckaus (1986):
Factor Accounts:			
a) Labour.	The closure rules are given by the exogenous determination of both labour supplies. Rural and urban labour supplies are available in fixed quantities, so that the wage rates adjust to ensure that the two types of labour are fully utilized.	The closure rule consists in that the wage rate is basically fixed. It is determined by some social rule, that is, the wage rate is set exogenously. This implies surplus labour in modern activities, while traditional sectors face under-employment of the labour force, which in turn, causes migration.	The closure rule is given by the exogenous projections of skilled labour supplies throughout the model's time horizon. Hence, the wage rate clears the labour market so that there is full employment of skilled labour in every time period.
b) Capital.	Similarly, homogeneous capital is assumed to be freely mobile across sectors and is inelastically supplied. Thus, capital stock is allocated so as to equate rental rates in all sectors, which in turn, guarantees its full employment. The constraint then, consists in the exogenous determination of capital stock.	Capital stocks are sector-specific which means that each capital has its own rental price. Since capital stocks are fixed this implies that the rental prices adjust so as to have full employment of the factor. Hence, the closure rules are determined by setting fixed quantities of capital stocks.	The amounts of capital stocks available in the base year are set exogenously. For subsequent years, however, they are determined endogenously, basically through the investment undertaken during each time period. The closure rules are then given by the amounts of capital stocks that can be used for production during the model's horizon.
Savings-Investment Account.	The current account deficit is exogenous and investment adjusts to the amount of available savings. The model is said to be savings driven and the closure rule is given by the exogenous determination of the trade deficit.	The constraint is imposed through a fixed trade deficit. Since the current account deficit is exogenous, investment is the residual by adjusting to savings in order to clear the savings-investment account.	The exchange rate is fixed and the model determines the amount of foreign exchange that can be borrowed from abroad, which in turn, clears the savings-investment account.
Numeraire of the System.	Not specified.	Not specified.	The exchange rate is the numeraire of the system. All prices are then measured relative to world prices and the domestic price level is based on a real foundation.
Type of Closure.	The closure rules for the factors and savings-investment accounts described above are known as neo-classical. Also, since prices adjust to clear all markets, the model is called flex-price.	The above-mentioned closure rules are basically Keynesian. On the other hand, given that prices depend on activity levels the model is of the flex-price type.	The closure of the system is essentially neo-classical. Also, the model is flex-price since prices are not independent of the scale of production.

investment acts as a residual adjusting to savings, whereas in (B-E) investment is determined via intertemporal optimization and borrowing from abroad clears the account.

A general conclusion that can be drawn from the above analysis is that closure rules not only permit the closure of a model, but because of that, they also affect the allocation of resources of a system and, consequently, the policy conclusions about the issues on which any macro-model focuses. Thus, the choice of macroclosures and the issues the researcher wants to explore are related subjects. Therefore, it can also be said that closure rules in addition to the issues themselves are some of the determinant factors in the choice of the type of model.

On the basis of the preceding comparative evaluation of the three SAM-type models for Mexico, it can be concluded that the selection of a model basically depends on the following three factors: the economic or policy issues to which the researcher wants to give special attention; the demands that they make for data, time, and resources of expertise and computational capabilities; and on the economic behaviour underlying the models, including closure rules.

In the following section, the SAM analytical framework shall be used again, in this case with the purpose of formulating the one-period version of the present model, which will also be compared against the three GE models reviewed above.

4.2 The SAM Structure of the Model.

The model is based on the SAM analytical framework because of the advantages that this approach represents to macro-modeling, namely: choosing the classification of accounts appropriate to address the three energy-economy interactions identified in chapter II; checking if those accounts satisfy the completeness condition; and understanding the model's behaviour. This section is divided into three subsections as follows:

(1). Classification of Accounts.

To begin with, this section shall first refer to the classification of accounts explaining the considerations behind the disaggregation chosen, and how it compares with the disaggregation adopted by the three models reviewed previously. To do so, the discussion is based on the SAM of Table 4.1. Bearing in mind that the classification of accounts was divided into the following four modules:

(a) Factor Accounts:

The model contains sixteen primary factors of production; three of which correspond to different labour categories: skilled urban, non-skilled urban, and rural labour. The remaining thirteen primary inputs are the sector specific capital stocks [17].

[17] In addition to primary factors, the production structure of the economy also employs intermediate inputs and non-competitive imports.

This particular level of disaggregation for factor accounts was chosen for two main reasons. Firstly, regarding the labour account, it was seen in section 2.2 that the labour force in Mexico is not homogeneous, and in particular, the supply of skilled labour is relatively scarce. Clearly then, if one of the purposes of this study is to analyze energy-labour force interactions, that is, to assess the extent to which the economy's absorption of oil resources is restricted by the shortage of skilled labour, and how different energy policy scenarios will affect the allocation of labour throughout the economy and, consequently, its shadow price, it is essential to separate the labour force by skill categories. The three labour groups identified here are intended as a compromise: one that is sufficiently aggregative so as to make use of existing Mexican statistics, as well as to handle the model, and sufficiently disaggregated so as to distinguish the basic skill-mix of alternative investment projects.

This degree of labour disaggregation is higher than that followed by any of the three GE models reviewed in Table 4.2. (SP) distinguishes two types of labour: rural and urban, while (RH) and (B-E) use only one class of labour [18].

For the moment, however, this subsection shall only refer to those inputs that generate value added.

[18] Some other GE models carried out for Mexico have used a more disaggregated labour force. Manne (1973), for example, classifies labour into five skill categories in formulating Dinamico (see section 3.2).

Secondly, with respect to the disaggregation of the capital account, the assumption is that capital is sector specific. Thirteen types of capital therefore exist, each of which is to have its own rental price. That is, capital goods differ according to the sector of destination (e.g. capital in the service or agricultural sectors is not the same 'stuff' as in the manufacturing sector), which means that once in place, capital is not shiftable, so that there are separate capacity constraints in each sector [19].

Both (RH) and (B-E) also postulate sector-specific capital technologies, whereas (SP) assumes that capital is freely mobile across sectors and is allocated so as to equate rental rates in all sectors. This neoclassical assumption implies a degree of perfection in capital markets that is not consistent with empirical observation in developing countries (see Dervis et al., 1982). Above all, freely mobile capital also means exante and expost substitutability of capital for labour (i.e "putty-putty" technology), where any particular item of capital could be costlessly and instantaneously 'moulded' so as to be suitable for operation by any number of workers. So, the capital-labour ratio of the economy could be varied at any time. A more plausible scenario of the technology is thus given by the assumption of sector-specific capital stocks.

---

[19] Since capital is sector specific, each sector in the economy also has its own depreciation rate and its own rate of capital accumulation or gestation lag. See the capital capacity constraint equation of section 5.2.

(b) Households:

Since the appropriate choice of disaggregation in a model is relative to the issues the researcher wants to explore, and given that income distribution is not one of the main concerns in the present study, no attempt is to disaggregate household groups. Thus, unlike (SP) and (RH) where individual classes of consumers are identified (see Table 4.3), this model is based upon the assumption of a 'representative' household.

(c) Domestic Commodities and Imports:

The representative household consumes the following nine domestic goods and services:

(1) Agriculture.
(2) Mining.
(3) Refining products.
(4) Manufacturing of capital goods.
(5) Manufacturing of intermediate and consumption goods.
(6) Electricity.
(7) Transport.
(8) Commerce.
(9) Services.

Based on the 1980 I-O Matrix the consumption index excludes oil and gas, petrochemicals, construction and government services (which appear as production activities). Construction is delivered entirely to investment, while government services are delivered entirely to government consumption.

On the other hand, two types of imports are distinguished in the model: competitive and non-competitive. The reason is that in the specification of macro-models for open economies, an "intra-trade" problem usually arises. That is, even with a highly disaggregated product classification, there are simultaneously imports and exports at the same time within individual product groups. Obviously, the assumption of homogeneity between domestically produced and imported goods, which is generally made in trade theory (as seen in section 4.1), cannot be maintained. One way of approaching the problem is, precisely, to differentiate between competitive and noncompetitive imports [20]. The former are discretionary, and refer to goods which could be produced domestically although perhaps at higher cost. Non-competitive imports consists of goods which cannot be produced in the country. They are demanded mostly for intermediate consumption, and are better thought of as another factor of production [21].

(d) Production Activities:

The economy has 13 producing sectors: 4 non-oil traded sectors, 6 nontraded sectors and 3 oil related sectors. To give an idea of the type of aggregation that is used in the model, Table 4.9 sets up the correspondence of the producing sectors in the model to the 72 sectors which are recognized in the 1980 I-O matrix.

---

[20] For a discussion of alternative methods of approaching this problem see Fischer et al., 1982.

[21] (SP) and (RH) do not distinguish between imports, but rather assume that they constitute a homogeneous good. See Table 4.2.

Table 4.9
General Equilibrium Model Sectors:
Correspondence to 1980 Input-Output Matrix.

GE Model Sectors	1980 I-O Matrix Sectors
I. Non-oil Traded Sectors:	
Agriculture.	1) Agriculture.
	2) Livestock.
	3) Forestry.
	4) Fishing & hunting.
Mining.	5) Coal & its products.
	7) Iron mineral.
	8) Metalic nonferrous minerals
	9) Quarries, sand, gravel,clay
	10) Other non-metalic minerals.
Manufacturing of interme- diate and consumption goods.	11) Meat & milk products.
	12) Fruits and legumes.
	13) Wheat & its products.
	14) Corn & its products.
	15) Coffee.
	16) Sugar.
	17) Vegetable estable & oils.
	18) Food for animals.
	19) Other food products.
	20) Alcoholic beverages.
	21) Beer.
	22) Soft drinks.
	23) Tobacco & its products.
	24) Bland fibers.
	25) Hard fibers.
	26) Other textile industries.
	27) Clothing.
	28) Leather & its products.
	29) Sawmills.
	30) Other wood industries.
	31) Paper & pasteboard.
	32) Printing & editorials.
	35) Basic chemicals.
	36) Fertilizers.
	37) Sintetic resins, plastics.
	38) Medical products.
	39) Soaps, detergents, perfumes
	40) Other chemical products.
	41) Oilcloth products.
	42) Plastic products.
	43) Glass & its products.
	44) Cement.
	45) Other non-metalic products.
	46) Basic iron & steel indust.
	47) Nonferrous metals basic ind
	59) Other manufactures.

Manufacturing of capital goods.	48)	Metalic furniture & acces.
	49)	Structural metal products.
	50)	Other metal products.
	51)	Non electric equi. & mach.
	52)	Electric equipment & mach.
	53)	Household appliances.
	54)	Electric equipment & acces.
	55)	Other electric equipment.
	56)	Automobiles.
	57)	Automotive bodies & parts.
	58)	Other transport equi. & mat
II. Non-Traded Sectors:		
Construction.	60)	Construction and installations.
Electricity.	61)	Electricity.
Commerce.	62)	Commerce.
	63)	Restaurants & hotels.
Transportation.	64)	Transportation.
	65)	Communications.
Services.	66)	Financial services.
	67)	Real property rent.
	68)	Professional services.
	69)	Educational services.
	70)	Medical services.
	71)	Diversion services.
	72)	Other services.
Government.		Government consumption*.
III. Oil Related Sectors:		
Crude oil & natural gas.	6)	Oil & gas extraction.
Refining products.	33)	Petroleum refining.
Petrochemical products.	34)	Basic petrochemicals.

* Obtained from final demand.

This Table reflects the main concern of the model: to understand the interaction of the energy sectors with the economy as a whole. Non-oil sectors of the economy are basically aggregated according to three interrelated reasons. First, they are aggregated much in line with their patterns of energy usage, as well as the implicit consumer demand for them. This is the reason why transportation, for example, is treated as a separate production sector [22].

Second, given that we are dealing with products in an open economy, a distinction is made with respect to tradeability. In Table 4.9, construction, electricity, commerce, transportation, services and government services are considered as non-traded goods, and all other non-oil sector products as traded goods. This explains the fact that mining, for example, is treated as a separate sector despite that it is about one-seventeenth the size of the largest non-energy production sector (manufacturing of non-capital goods) [23]. Finally, in order to assess the impact that energy policy has on industry and, specifically, on the capital goods' manufacturing sector, this sector is separated from the rest of manufacturing goods [24].

On the other hand, oil related sectors are disaggregated so as to allow easy examination of different energy policies. As the oil sector can be split

---

[22] Recall from section 2.1 that one of the issues we want to analyze is the effect of different domestic energy consumption scenarios on oil exports, GDP growth, consumption, etc. Since the transportation sector is one of the main consumers of energy, it is crucial to separate it from the rest. The same is true for both manufacturing sectors.

[23] In 1980, the mining sector was the fifth largest export sector in the Mexican economy, behind the oil and gas extraction sector, the two manufacturing sectors, and tourism (captured in the commerce sector).

[24] As explained in section 2.1, the capital goods' manufacturing sector is the less developed sector of the Mexican industry and where most of the country's imports come from. This, and the rest of manufactures, are the sectors more likely to suffer from the Dutch Disease phenomenon.

into two different but interconnected industries, namely, the industry of production and extraction and that of refining and petrochemical products, the latter industry has been divided into oil refining and basic petrochemicals. This distinction is important because we can study, for example, what feasible growth rates can the petrochemical industry achieved in accordance with different energy-economy scenarios [25].

As explained in Table 4.2, (SP) distinguished 15 final consumption goods and 14 production activities, while (RH) has 19 activities and commodities [26]. Nonetheless, the oil sectors are less disaggregated in relation to Table 4.9. They aggregated petroleum, refining and petrochemicals in one sector, which is understandable given the respective purposes of both studies [27].

Moreover, the software used in this study has allowed the incorporation of more disaggregated production accounts than the ones used by (B-E) [28]. There are four basic improvements in this respect. First, refining and petrochemical products are separated; second, the

[25] Nowadays, the petrochemical industry is undergoing a world-scale crisis far graver than that suffered by international crude trade. See Wionczek (1987).

[26] As stated in section 4.1, these two studies are static, that is, the models are set to one period only, which implies that they do not have to disaggregate the model into several time periods. This is not the case with the present study or the (B-E) model, as they are multi-period models and, consequently, face more computational limitations regarding the degree of disaggregation of the production sectors.

[27] May-Kanosky (1983) disaggregated the refined products but only for the demand side. In an I-O framework this means that the row for refined products is split in five, while the column, which contains the cost structure of the sector, was not disaggregated.

[28] See section 5.3 for a discussion about the software package used in the solution of the model.

manufacturing sector is split into its two main components: capital goods and the rest; third, mining constitutes a single sector; and fourth, commerce and service sectors are divided. Again, the different purposes of both studies explain these modifications.

In sum, since all modelling involves a trade-off between theoretical tradeability and empirical verisimilitude, the degree of disaggregation chosen reflects a model that tries not to be too complex for optimization, but at the same time, attempts to have sufficient economic structure so as to address the particular energy-economy policy issues relevant to the Mexican economy. Thus, the difference in the degree of disaggregation of the SAM accounts between this model and the other three studies, is given by the different nature of the hypothesis and experiments that the present study wants to address. In particular, because this work sets out to analyze energy-economy issues, energy sectors are relatively more disaggregated. Similarly, since one of these issues is the relationship between energy-labour force, labour categories are also more disaggregated.

(2) Data Base.

The 1980 Input-Output Table represents the main data source of the model. This Table is the most recent data base that exists for Mexico [29], and takes account of the effects of the oil boom on the whole Mexican economy

[29] Recall that the information employed by the three GE models reviewed previously is based on the 1970 I-O matrix.

up to 1980 [30]. On top of that, the 1980 I-O matrix identifies more accurately the different oil related activities than previous matrices by introducing a new classification of the production processes of Pemex, as well as by presenting a more plausible valuation of the transactions of the oil sector [31].

In addition, the last economic and population census published refer to 1980, which enables to obtain most of the data required in the model in the same base year [32].

(3). Behavioural Specification.

The SAM framework is also useful for presenting a description of the static version of the model. At the same time, this allows to examine if the SAM accounts satisfy the completeness condition. That is, given that within any economic system all incomes must be matched by corresponding expenditures, a model is said to be complete if and only if it satisfies such condition: the sum of all rows must be equal to the sum of all columns (see Pyatt, 1987).

The description of the one-period version of the model is carried out on the basis of the accounts appearing in

---

[30] (B-E) (1986a, p.261), acknowledge that "... the presentation and discussion of the solutions cannot be interpreted as providing currently valid analysis of the Mexican economy. ...it was necessary to use rather rough, often outdated estimates for much of the data". In particular, their data base ignores the 1978-81 oil shock which dramatically affected the course of the Mexican economy, as explained in section 1.3.

[31] See, 1980 Input-Output Matrix (1986, pp. 4-5).

[32] For a description of the way in which the data base of the model was calculated see Appendix A.

the SAM of Table 4.1, which are divided in the following five modules:

(a) Factor Accounts:

There are sixteen factor of production accounts in the model: three labour accounts and thirteen capital accounts. For the sake of simplicity, Table 4.1 only shows one account for labour and one for capital [33]. The only source of income for each input is the value added payments made by the production activities in return for factor services (rows 1 and 2). On the other hand, since factor services are owned by either households and government, this income accrues to the domestic institutions in the form of wages and profits (columns 1 and 2). The allocation of this income is made in proportion to the ownership of each factor by the different institutions. These proportions add to 100 percent, so accounts 1 and 2 are balanced.

(b) Institutions' Current Accounts:

The model distinguishes two domestic current account institutions: household and government [34].

(i) Household:

In order to introduce substitution possibilities in household-consumption patterns and internalize the

---

[33] The fully disaggregated SAM would contain one separate account for each of the sixteen inputs.

[34] In the accounts shown by Table 4.1, "enterprises", a typical account present in many SAMs, does not appear as a separate institution because it is not treated in the model as behaviourally distinct from producers (activities). This simple treatment seems reasonable given the issues on which the present model focuses, but should be expanded in models concerned more with income distribution, taxation, etc.

savings decision, a generalized logarithmic price-sensitive consumption demand function or Extended Linear Expenditure System (ELES) is used, where the existence of a representative consumer is assumed [35]. This system is implicit in account 3. Row 3 shows the sources of household's income: wages, non-oil profits, government transfers, and foreign remittances. In column 3 the representative household spends its income in consumption of goods, paying direct taxes to government and, as the residual is saved, this therefore guarantees that account 3 is balanced. The ELES is defined next:

$$U_t = (1+ \ )^{-t} \ \bar{N}_t \sum_{i=1}^{9} v_i \ln (C_{i,t} / \bar{N}_t - c_i)$$

where:

- = Four-year rate of time preference of utility.
- N_t = Level of population, year t.
- v_i = Marginal expenditure share on consumption of good i; $\sum v_i = 1$.
- $C_{i,t}$ = Consumption demand for good i, year t.
- c_i = Minimum level of per-capita consumption of good i.

Briefly, the problem facing the household can be put in the following terms: given a spendable amount per unit of time (per capita disposable income), and a set of commodities (nine in this case because the consumption index includes all sectors except oil and gas, petrochemicals, construction and government services), how much is spent on each commodity, and how much is

---

[35] ELES has often been used in planning models to characterize consumer demand. For a discussion of ELES and its application to several countries see Lluch et al. (1977). For a more formal treatment of LES in general, and the econometric procedures for its estimation, see Powell (1974).

saved? [36]. Total consumption is captured in a two-level decision-making process: (i) is the identification of the minimum level of per-capita subsistence or committed consumption of each item (c_i); and (ii) is the allocation of the remaining discretionary consumption across the nine sectors, or the expenditure above that required for purchasing the subsistence minima, ($\Sigma v_i = 1$).

Since in ELES, the representative household decision is assumed to be made on a per capita basis, consumption has to be multiplied by population ($\bar{N}_t$) to obtain total consumption in each period, properly discounted (at a rate i). In optimizing models, non-linear functions such as the ELES can be introduced but only if they are mathematically convex and separable [37]. This means that the marginal utility of consumption for each good must be declining and depend only on the level of consumption of that commodity. These convenient features are present in ELES [38]. On top of that, in contrast to other consumption functions where total consumption expenditure is predetermined, the ELES calculates it endogenously,

---

[36] One of the advantages of ELES over LES is that in the former the income responsiveness of demand for commodities and of saving is sufficient to imply how demand would respond to prices. See Luch et al., 1977 pp. 15-16.
[37] This equation could not be entered directly in (B-E) because the software used in the solution did not allow them to depart from linear structure. Hence, they had to employ piece-wise approximations in order to linearize the ELES. By contrast, as shall be explained in section 5.3, the software used in the present study does handle non-linear equations and, therefore, allows the incorporation of the ELES equation directly in the model. Consequently, substitution possibilities between consumption expenditures do not have to be prespecified as in (B-E).
[38] The ELES also fulfills the general restrictions of any demand function, namely: the Engel aggregation, as well as the additivity, homogeneity, and simmetry conditions. For a detail analysis of the implications of these conditions see Phelps (1974).

and consequently, endogenizes the savings decision too [39]. In short, the intertemporal and the intercommodity aspects of household's decision making are unified in ELES.

With this formulation, no explicit constraints are needed on the consumption-savings breakdown nor are minimum or maximum values for any particular consumption good required to avoid temporal or sectorial concentration of consumption, as may otherwise happen in optimizing models [40]. Rubinstein (1977) has also offered a host of arguments as to why a ELES should be favoured in finance models for analyzing intertemporal choice, particularly under uncertainty.

(ii) Government:

Government receives income from several sources: direct taxes, indirect taxes on commodities, and profits (row 4). Regarding profits, since the Mexican government owns mineral rights, it receives all oil profits. Total government income is then allocated in column 4 either as transfers to household or abroad (e.g. interest payments on foreign debt), or as current consumption. Income that

---

[39] For a review of alternative demand functions see Powell (1974). Goreux (1977), on the other hand, presents a detailed discussion of using price-sensitive consumption demand functions in economy-wide models.

[40] In an earlier exercise, a simplified version of this model was solved, which among other differences with the complete one, included a linear consumption function. In this case, the pattern of consumption did not vary with the endogenous prices which the model computes when using the ELES. In addition, smoothing constraints were needed to guard against excessive swings in aggregate consumption up or down between periods.

is not allocated in this way is saved, which guarantees the balance of account 4.

(c) Institutions' Capital Accounts:

The next module in Table 4.1 corresponds to the domestic capital account institutions, also known as savings-investment accounts (accounts 5 and 6). Total savings are gathered in row 5, and they are obtained from household and government savings, and from external capital transfers. Savings are then allocated to increase the capital in each of the thirteen producing sectors. If there is any difference between total savings and their allocation into investment expenditures, this goes to increase or decrease in reserves, which preserves the balance of this account.

The investment allocations (row 6) are then translated into commodity demands in column 6 through the capital share matrix (B matrix) [41]. The translation means that goods are required in fixed-quantity ratios which add up to one so that account 6 is balanced.

(d) Production Accounts:

This module is composed of activities and commodities. This separation is important in a modeling framework because, as already explained, activities correspond to the producing sectors in the I-O accounts, whereas commodities refer to the domestic market for all

[41] The B matrix captures the investment expenditures by both sector of origin (typically, construction and machinery and equipment), and sector of destination.

products, with supplies coming from producers and imports.

(i) Activities:

Given the importance of the oil sector for the Mexican economy, Table 4.1 splits production into non-oil and oil and gas extraction activities. In order to produce commodities, both activities purchase four categories of inputs: labour, capital, intermediate inputs and non-competitive imports. Columns 7 and 8 capture the payment to primary factors of production for their services (or value added), which together with the demand for intermediate inputs and non-competitive imports represent the total costs of production. Rows 7 and 8 represent accruals by activities from the sale of commodities either domestically or via exports. This revenue is partially offset by the purchase of raw materials and the remainder is, by definition, value added. This residual ensures that the sum of rows 7 and 8 equals the corresponding columns.

Substitution between sector specific capital and the three types of labour (i.e. rural, skilled urban and non-skilled urban) is allowed through a constant returns Cobb-Douglas (C-D) production function with endogenous factor and goods prices.

$$X_{i,t} = \bar{A}_i \; L_{i,1,t}^{\alpha_{i,1}} \; L_{i,2,t}^{\alpha_{i,2}} \; L_{i,3,t}^{\alpha_{i,3}} \; K_{i,t}^{\alpha_{i,4}}$$

where:

$X_{i,t}$ = Gross output of sector $_i$, year $_t$.
$\bar{A}_i$ = Constant shift parameter of sector $_i$.
$L_{i,s,t}$ = Demand by sector $_i$ for skill category $_s$, year $_t$.
$\alpha_{i,s}$ = Input share parameters; $\alpha_{i,4} = 1 - \Sigma\, \alpha_{i,s}$
$K_{i,t}$ = Demand for capital by sector $_i$, year $_t$.

A C-D technology was chosen for a number of reasons: First, several studies carried out for Mexico conclude that a constant returns C-D production function is the most convenient specification of the technology to generate value added [42].

Second, in designing an equilibrium model, it is convenient to choose functional forms that simplify the estimation of numerical parameters. It is typical to employ 'benchmarking' procedures to evaluate parameters such as $\bar{A}_i$ and $\alpha_{i,s}$ (see Appendix A). So, benchmarking estimation of parameters accounts for the popularity of a C-D functional form. More general production functions (e.g. translog) provide greater flexibility, but they also require more data than is normally available [43].

Third, this specification will help to avoid knife-edge behaviour of the shadow price with respect to the exogenously specified availability of labour skills [44].

---

[42] Some of these studies are: Syrquin (1969), Trejo (1973), Sidaoui (1979), Serra-Puche (1979), and Reyes Heroles (1983).
[43] On the pros and cons of benchmarking versus more elaborate econometric estimation procedures, see the interchange between Lau (1984) and Mansur and Whalley (1984).
[44] Manne (1973), for example, reported that employing exogenously projected skill supplies together with a Leontief technology, the efficiency price differentials between skill groups were either zero or unbelievably large. Apparently, there was insufficient indirect

However, a C-D technology is also likely to imply full employment of primary inputs because of the unitary elasticities of substitution [45].

Fourth, in contrast to (B-E), where seven substitution activities were prespecified for five of its nine sectors on the basis of fixed coefficients, the algorithm used here allows the introduction of a truly price-sensitive neoclassical production function such as the C-D for all sectors. In principle, a C-D technology would lead to a model with more attractive price structures than those generated by piece-wise approximations [46].

The remaining demand for the two other inputs is calculated in the usual way through a matrix of I-O coefficients, or Leontief system. The demand for intermediate inputs is given by:

$$INT_{i,t} = \sum_{j=1}^{13} a_{i,j} \; X_{j,t}$$

where:
$a_{i,j}$ = Intermediate input of good i, per unit of gross output in sector j; or technical coefficients.

For each sector then, the demand for intermediate inputs is a fixed-coefficient function of the activity levels of gross output in a particular year. There are some variations among sectors. For instance, there are no intermediate demands for either construction (delivered

---

substitution via international trade to avoid knife-edge behaviour of the shadow price of labour.

[45] See section 7.1 for an analysis of sensitivity to alternative elasticities of substitution.

[46] Section 5.3 explains some of the difficulties associated with the use of linear approximations.

entirely to investment) or government services (delivered entirely to government consumption).

Similarly, the demand for non-competitive imports is linked to gross output, but in addition, it also depends on the level of investment by sector of destination. All this is done through a fixed-coefficient technology.

$$NCI_t = \sum_{i=1}^{13} nm_i \; X_{i,t} + nmc_i \; DK_{i,t}$$

where:
nm_i = Non-competitive import demand per unit of gross output of sector i.
nmc_i = Non-competitive import demand per unit of investment in new capital stock in sector i.

Hence, non-competitive import demanded by the several sectors for current production and investment are obtained via multiplication by two diagonal matrices (nmi and nmci), containing the fixed sectorial requirements coefficients. In sum, production technology for all sectors in the model combines a Leontief system for intermediate inputs and non-competitive imports, with a C-D function that generates value added from primary inputs.

(ii) Commodities:
Since domestic production and imports represent the two main sources for the total supply of any commodity, Table 4.1 divides commodities in accounts 9 and 10. Rows 9 and 10 show total domestic commodity demand valued at market prices. Accordingly, the supply of both domestic and imported goods (columns 9 and 10) must be valued

similarly: indirect taxes are included in the cost of total domestic commodity supply.

Another way of showing the balance of the commodity accounts is by looking at rows 9 and 10 where the different sources of commodity demands are present: intermediate deliveries which, as already explained, are used in production by each sector, and final demands: private consumption, government consumption and investment. These demands are met by competitive imports and domestic goods (columns 9 and 10).

With the exception of exports, which are captured in rows 7 and 8, accounts 9 and 10 are equivalent to the material balance equation. The material balance constraints insure that for each good, total supply is at least as great as total demand.

$$M_{i,t} + X_{i,t} \geq INT_{i,t} + C_{i,t} + \bar{G}_{i,t} + I_{i,t} + E_{i,t}$$

where:

$M_{i,t}$ = Competitive imports of good $_i$, year $_t$.
$INT_{i,t}$ = Intermediate deliveries of good $_i$, year $_t$.
$G_{i,t}$ = Government consumption of good $_i$, year $_t$.
$I_{i,t}$ = Investment deliveries of good $_i$, year $_t$.
$E_{i,t}$ = Exports of good $_i$, year $_t$.

As already explained, competitive imports are discretionary, and refer to goods which could be produced domestically, although perhaps at higher cost [47]. $\bar{G}_{i,t}$ is forecast on the basis of an exogenous growth rate applied to the initial vector of government consumption

[47] The other category of imports, non-competitive imports, do not appear in the balance above because they do not increase supply of the produced goods considered in the model. As seen before, non-competitive imports are treated as another factor of production.

(see Appendix A). This allows the possibility of using the rate of growth of government consumption as a policy variable in different numerical experiments. See the relevant sub-sections for the description of how the other components of this equation are determined.

(e) Rest of the World Account:
The last module of Table 4.1 shows the transactions between the domestic economy and the rest of the world (ROW) (account 11). Mexico receives income from abroad in payment for exports and, similarly, it pays to the ROW for imports. In addition, the Mexican economy receives capital transfers from abroad and makes corresponding payments (e.g. interest payments on foreign debt). The ROW account is balanced by including the increase or decrease in reserves which adjusts the difference between foreign exchange payments and receipts of Mexico.

The ROW account is modelled through the foreign exchange balance equation. This equation restricts the foreign exchange that can be spent on imports and on debt servicing to be equal to foreign exchange revenues generated through exports, and capital inflows to both the public and private sectors of the economy.

$$\sum_{i=1}^{13} pm_{i,t} \; M_{i,t} + pnm_t \; NCI_t + IP_t =$$

$$\sum_{i=1}^{13} pe_{i,t} \; E_{i,t} + B_t$$

where:

$pm_{i,t}$ = Border price of competitive imports of good i, year t.
pnm_t = Border price of non-competitive imports, year t.
NCI_t = Non-competitive imports, year t.
IP_t = Interest payments on foreign debt, year t.
$pe_{i,t}$ = Border price of exports of good i, year t.
B_t = Net total foreign borrowing, year t.

The modelling of interest payments and foreign borrowing is described in section 5.2. For now it suffices to emphasize that, since repayments are not included in the foreign exchange expenditures, total (public and private) borrowing is defined in net terms.

Exports of the two types of manufacturing goods are determined endogenously and are allowed to reach any feasible level subject only to capital, labour, non-competitive imports, and intermediate input requirements [48]. Exports of oil and gas, on the other hand, are additionally constrained by the oil export ceilings imposed by the government as shall be seen in section 5.2. The model then, chooses the optimal levels of oil and both manufacturing exports based on costs of production, domestic level of demand, needs for foreign exchange and the vector of export prices ($pe_{i,t}$). This vector is exogenous and can be changed to trace the Mexican economy's supply curve in various scenarios for the foreign conditions. The exports of the remaining

[48] Manufacturing exports were calculated exogenously in (B-E).

sectors are determined exogenously according to historical performances (see section 6.1) [49].

The two types of import cost functions, competitive and non-competitive, are also calculated endogenously by the model as functions of the quantities imported and, the exogenously given import price vectors. As seen before, non-competing imports, which cannot be produced in Mexico, are required in the model for production, and investment through input coefficients.

Foreign exchange values are measured in terms of 1980 pesos. This is purely an accounting convention, and these values can be converted to current pesos using procedures described in the discussion of shadow prices (see section 6.4).

The above are the basic within period SAM behavioural equations of the model. It has been shown that every account in Table 4.1 is balanced. The model then, is complete in the sense that all incomes and outlays are fully accounted for. On the other hand, while in (B-E) substitution possibilities between consumption expenditures, and between production activities had to be prespecified on the basis of fixed coefficients, the present model incorporates truly price-sensitive equations such as the ELES and the C-D production functions.

---

[49] A more sophisticated version of the model might incorporate endogenous export demand functions for all traded goods. This though, would be very expensive computationally.

Static CGE models, however, such as those of (SP) and (RH), or equivalently, the one-period version of the model shown in Table 4.1, set exogenously important variables as capital stocks and investment expenditures. By contrast, in a multiperiod optimizing framework, such as the intertemporal version of the model to be shown in chapter V, investment expenditures are calculated endogenously and, above all, allocated efficiently over the long-run planning horizon, as shall be explained in more detail in the next chapter.

Another difference between static or recursive models and multi-period optimizing models which is particularly important in this study, is that while in the former the production of oil and gas is fixed and, consequently, oil exports are simply the oil not used domestically (e.g. (SP)); in an intertemporal model oil and gas output and exports are optimized according to the specified objective function. This shall also be discussed in more detail in section 5.2.

For these reasons, the one-period version of the model will not be solved numerically. The numerical solution is implemented to the multi-period system. In addition to the SAM equations described above, there are some other behavioural rules required to determine endogenously investment, oil production and exports, and foreign borrowing in a non-recursive dynamic framework. These are examined in the next chapter.

CHAPTER V.

THE INTERTEMPORAL OPTIMIZING GENERAL EQUILIBRIUM MODEL.

This chapter describes the intertemporal model used to analyze the key long-term development interactions between the energy sectors and the economy as a whole, previously identified in the case of Mexico. The chapter is organized in three sections. Section 5.1 sets up the purpose of the model. Section 5.2 describes the intertemporal equations that are required in addition to the behavioural rules featured in the SAM shown in Table 4.1. Section 5.3 examines the software package employed in the solution of the model, and evaluates it against previous algorithms.

5.1 Purpose of the Model.

The model has been elaborated with the specific purpose of using it as an analytical framework for assessing the long-term implications of the interactions between: (1) energy-industrialization; (2) energy-labour force; and (3) energy-foreign indebtedness in Mexico. The GE dynamic optimizing model described in section 5.2 is an extended version of (B-E), discussed previously. However, given the particular nature of the experiments and hypothesis on which the present study focuses, the following five types of improvements have been introduced:

(i) Several improvements in the specification of behavioural and technical constraints are incorporated, some of which were examined in the previous chapter. Particularly, the model contains truly price-sensitive endogenous choices by virtue of various non-linear functions.

(ii) The way in which both the objective function and the terminal conditions are formulated is also different (see section 5.2).

(iii) As pointed out in section 4.2, there is a greater degree of disaggregation of the accounts appearing in the SAM, particularly regarding labour categories and energy and non-energy production sectors, in both activities and commodities.

(iv) The data base of the model is more updated (see Appendix A).

(v) A much improved software is employed for solving the model. This is examined in section 5.3.

All these modifications will facilitate the analysis of the above-mentioned energy-economy interactions. As indicated previously, virtually all these policy issues are of an intertemporal nature and, therefore, are best treated in the context of multi-period models, where time plays a critical role. Moreover, one conclusion drawn from the description of the static version of the model in section 4.2, is that static or recursive systems treat as exogenous several important long-range questions of macroeconomic planning, such as investment expenditures and oil exports. A multi-period non-recursive optimizing model, on the other hand, determines endogenously such key variables, which are optimized within the discrete-time horizon.

This type of model also calculates activity levels in each sector taking into account the intersectoral transactions. These activities are interconnected. For instance, an increase in the level of oil exports will affect the size and sectorial composition of output, require shifts in the allocation of capital and labour in the economy, will lead to adjustments in the investment patterns and will affect the optimal level of external borrowing. All this is done in a manner that maximizes the specified objective function, which ensures that the solution of the model has the desirable efficiency properties. This makes the dynamic optimizing framework the most plausible tool for analyzing the long-run implications of the set of interconnected policies and activities with which this study attempts to deal.

In addition to the SAM behavioural rules described in section 4.2, there are some other equations which are needed in order to construct an optimizing intertemporal GE model, such as updating equations and the specification of the objective function. These are explained in the following section.

5.2 The Optimizing Intertemporal GE Model.

The model is dynamic and a twenty-eight year time horizon was selected extending from 1980 to 2008 [1]. Ideally, a model of this type would generate, year-by-year, a complete set of economic accounts reflecting allocation and pricing decisions. Unfortunately, this temporal detail would be very expensive computationally and, therefore, a compromise is adopted. That is, the total planning period is divided into equal subperiods of four-years length. This means that the set of economic accounts is calculated every four years, and an interpolation procedure is invoked to link the sub-periods together.

Starting with 1980 as base year [2], the notation for the time index "t" used throughout is as follows:

Year, t	Calendar year
0	1980 (used only in setting initial conditions).
1	1984
2	1988
3	1992
4	1996
5	2000
6	2004
7	2008 (used only in setting terminal conditions).

As for the equations of the previous chapter, the symbols i and j are employed as row and column indices,

[1] In a model such as this, 15-20 years is regarded as an appropriate horizon because it takes some time to generate savings, convert them into capital, and to reallocate the different labour groups. In addition, investments in energy and other sectors are long-lived. Similarly, it takes a substantial time-period for the impact of relative price changes, for energy as well as other goods, to be fully reflected in demand patterns.

[2] The reasons of choosing 1980 as base year are explained in Appendix A.

respectively, for the 13 goods producing sectors. The symbol s identifies the three labour categories. Unless specified otherwise, all items are valued in terms of 1980 domestic producers' prices. Exogenous variables are denoted by capital letters with bars over them.

In order to make the model intertemporal, some updating equations are needed. These are explained next.

Factor Supply Constraints:

In each time period, the optimal solution of the model is constrained by the availability of each primary factor: labour, capital, and oil and gas. Labour supply by skill categories is not modelled explicitly and availabilities are assumed exogenously. On the other hand, capital creation and oil and gas extraction are a central part of the model and their behaviour is specified.

Starting with the labour market, the endogenously determined labour demand (across sectors) for each category is constrained to be less than or equal to the inelastic, exogenously projected labour supply in that category.

$$\sum_i L_{i,s,t} \leq \overline{LS}_{s,t}$$

where:

$\overline{LS}_{s,t}$ = Supply of skill category of labour $_s$, year $_t$.

Although in theory, and certainly in the programme, there is the possibility of inequality between demand and supply of labour, in practice the unitary elasticity of substitution of the C-D production functions described in section 4.2, forces the three labour supplies in each activity to be exactly the labour demanded for production [3]. In other words, unitary elasticities of substitution mean that a skilled labour to output ratio is not required, so that wages will adjust to clear the labour market. In alternative runs, however, the possibility of obtaining skilled labour shortages in the economy shall be explored by virtue of changing the elasticity values (see section 7.1).

Turning now to the capital capacity constraints, the amount of capital available in each year is a function of initial endowments, rates of accumulation, depreciation rates, and the investments decisions that the model has made for prior periods (9). As explained earlier, once in place capital is not shiftable to a different sector (putty-clay technology), so that there are separate capacity constraints for each industry. Accordingly, separate depreciation rates and gestation lags are used in each sector. Sectorial production is, therefore, constrained by the availability of sector-specific capital formation in each period. This equation is sometimes referred to as capital capacity constraint.

[3] The implications of this specification for the shadow price of the labour force are explained in section 6.4.

$$K_{i,t} \leq \bar{K}_{i,0}\,(1-d_i)^t + f_i \sum_{g=1}^{t} (1-d_i)^{g-1}\, DK_{i,g}$$

where:

$\bar{K}_{i,0}$ = 1980 capital stock in sector $_i$.

d_i = Four-year depreciation rate of capital stock in sector $_i$.

f_i = Four-year accumulation rate of new capacity in sector $_i$ per unit of investment.

$DK_{i,g}$ = Investment by sector $_i$ in previous periods (^{g}).

There are three important points to notice about the capital capacity constraints. The first is that investments in each period determine the capital stocks available for production in the next and following time periods, including the terminal year (2008). Second, terminal year capital stocks by sector ($K_{i,7}$) are calculated efficiently in this equation as part of the optimization programme. Since investments determine capital stock formation, $K_{i,7}$ then insures that there will be adequate investment in the terminal year to support future, post-terminal growth. The resulting terminal capital stocks are then placed in the objective function in order to avoid the model devoting all resources in the terminal year to consumption. This is further explained later on when the objective function of the model is described.

Third, in contrast to earlier optimizing models, where the norm was to use uniform gestation lags of identical length as the time intervals between periods, here sector-specific aggregation coefficients are identified. The idea is that since investment in any one year determines the capital stock accumulation over a four-year period, the aggregation coefficients are close to four. However, they are somewhat greater than four in sectors with short gestation lags or higher expected growth rates, and below in opposite situations [4].

Since the distribution of base year investment by sector of destination ($DK_{i,0}$) is unknown, its sectorial allocation has to be estimated endogenously which results in some loss in realism. The model allocates the 1980 exogenously given total investment in the most efficient way according to the objective function and post-base year constraints.

$$\sum_{i=1}^{13} DK_{i,0} = \bar{I}_0$$

where:
$DK_{i,0}$ = 1980 Investment by sector of destination i.
$\bar{I}_0$ = Total investment in 1980.

Before talking about how oil and gas extraction and reserves are modelled, the natural way to proceed now is to refer first to the behaviour of investment by sector of origin.

Investment:
Investment expenditures among the different sectors are calculated endogenously. This is done using fixed coefficients which relate one unit of capital in each

[4] For a discussion of the relationship between gestation lags and the accelerator coefficient see Blitzer (1972). Manne (1974), on the other hand, comments about the simplifications adopted by earlier optimizing models respect the aggregation coefficients.

sector to deliveries of specific goods produced by the investment goods sectors (eg. construction, machinery and equipment, etc).

$$I_{i,t} = \sum_{j=1}^{13} b_{i,j} \; DK_{j,t}$$

where:
$b_{i,j}$ = Demand for capital good $_i$ per unit of investment of sector $_j$; or B matrix.

One of the main features of the multi-period optimizing approach is that it determines the optimal or efficient level and composition of investment over the long run planning horizon, as was indicated in section 4.2. The above equation means that total demand for investment goods produced by a given sector is calculated applying the matrix of investment shares ($b_{i,j}$) [5], to the required levels of new capacity ($DK_{j,t}$) and to all sectors which the model decides efficiently, given its maximization problem. Efficiency in investment is achieved because the endogenous mechanism that regulates capital accumulation in optimizing models is supported by the assumption that economic agents make today's decisions based on tomorrow's alternatives, and so, they can check the consistency of their expectations. This contrasts with recursive CGE models, where investment is either fixed or is myopically determined [6].

---

[5] This matrix reflects the composition, in terms of goods, of the sectorial capital formation.
[6] For a further discussion about the determination of investment expenditures in CGE and optimizing models see Dervis et al. (1982), Bell and Srinivassan (1982), and Manne (1985).

Oil Reserves and Extraction:

The model chooses endogenously the optimal level of hydrocarbons production and consequently of reserves based on the following equations:

$$R_{t+1} = R_t - 4\ EXT_t$$

$$EXT_t = q\ X_{3,t}$$

$$EXT_t \leq \overline{EXT}_t$$

where:
R_t = Oil and gas reserves, year t.
EXT_t = Extraction of oil and gas, year t.
$\overline{EXT}_t$ = Upper bound on oil extraction, year t.
$X_{3,t}$ = Gross output of sector 3 (oil and gas extraction), year t.
q = Extraction of oil, millions of barrels per unit of gross output of the oil and gas sector.

The first equation shows that cumulative extraction of oil and gas is subtracted from the initial endowment of reserves in each period. The remaining level of reserves available after the final plan year (R_7), is entered in the objective function so as to provide a social valuation of oil reserves and prevent its indiscriminate use (see the objective function further down). Hence, proved reserves are updated every time period by subtracting current production levels [7].

The first equation also assumes that there is a one-to-one relationship between depletion and extraction; that is, each barrel of oil production reduces reserves by exactly one barrel, which results in a linear specification. This formulation differs from the one used

[7] No new oil discoveries are projected, as occurs, for example, in Martin-van Wijnbergen model discussed in section 3.3.

by (B-E). They postulated a non-linear function where beyond certain point, increased production implied significantly greater depletion of oil and gas reserves. No theoretical explanation was found for this assumption, and rather this statement forces the model to choose a lower hydrocarbons production level than it otherwise would. Setting depletion equal to extraction would then allow the model to choose the appropriate level of oil production given the endogenous domestic demand and needs for foreign exchange, and the exogenously projected changes in international oil prices.

The second equation simply describes how the model converts gross output of the oil and gas extraction sector (in 1980 billions of pesos) into extraction in millions of barrels. The third equation, on the other hand, indicates that upper bounds on yearly extraction levels are specified given that the Mexican government has imposed crude production ceilings since the setting of the National Energy Programme in 1980 [8].

<u>Foreign Borrowing and Debt Service</u>:

Foreign borrowing and the burden of debt service payments represent crucial variables in this model. The choice of how much to borrow and/or how much to repay is modelled by the following equation:

---

[8] In order to evaluate the optimal pattern of oil and the government's decision to impose upper ceilings, these bounds can be modified in different policy experiments (see section 7.3).

$$D_t = \bar{D}_1 + \sum_{g=1}^{t} B_g$$

where:
D_t = Accumulated foreign debt, year t.
$\bar{D}_1$ = Accumulated foreign debt to 1984.
B_g = Net foreign borrowing in prior periods.

Making the time path of borrowing endogenous simulates actual policy choice and allows the economy to simultaneously adjust the level of domestic economic activities. Also, by weakening the foreign exchange constraint described in section 4.2, the economy is allowed to increase imports and/or reduce oil and manufacturing exports. However, foreign borrowing must be repaid either before or after the model's time horizon (as a terminal condition on the maximand: D_7). In effect, as shall be explained below, the objective function places a penalty on the level of post-terminal debt. Note also from the above equation that the level of accumulated foreign debt in 1984 is exogenous.

The cost of borrowing is assumed to be constant throughout. Specifically, the following equation is employed which relates the fixed interest rate on foreign debt to accumulated foreign debt.

$$IP_t = r\ D_t$$

where:
IP_t = Interest payments, year t.
r = Real interest rate on foreign debt.

As with all other variables in this model, interest payments are calculated in real terms, excluding the effects of inflation of the currency in which the debt is denominated. The choice then, of how much to borrow in net terms (B_g) and debt service payments (IP_t) is made endogenously by comparing the shadow value of foreign exchange and the marginal interest costs.

Objective Function:

An optimizing model relies heavily on the choice of the objective function to be maximized. As explained earlier, all activity levels are calculated in the model according to the specified objective function. In other words, the solution process in these models is based upon the central authority paradigm, where a central planner, fully in control of the various quantity variables in the system, and subject to several constraints, has to maximize a specific goal. However, as Dervis et al. (1982) outline, with few exceptions most economies in the world are characterized by situations where many agents independently maximize their own utility functions, which can be affected only indirectly by the planner.

Moreover, although it would be ideal for a researcher if the choice of one economic policy over another could be evaluated in terms of a single goal that is well established, identified, and agreed upon, the reality is not so simple. In fact, there are always many relevant planning objectives, which are often conflicting, and as Loucks (1975) explains, the importance of each one is rarely made precise before decisions are made. In practice, it is also difficult to determine on an a priori basis, the explicit trade-offs between partially complementary and conflicting goals, and, consequently, this leads to selection and implementation of plans which fail to meet many of the objectives to the extent originally envisioned. Choice is further complicated by uncertainty in the outcome of any decision and by practical limits on simultaneous consideration of all relevant information [9].

Therefore, it is not enough that a development plan be logically consistent given the various goals which policy makers may want to consider in selecting a plan [10]. The problem then, is how to choose one simple measure of aggregate benefit. The starting point is that, since the main purpose of economic development is to maximize social welfare, then the objective function of an optimizing model should provide a reasonable approximation to a social welfare function [11].

---

[9] For a further discussion about the role of the objective function in optimizing models, see Loucks (1975). Adelman and Sparrow (1966), on the other hand, examine the effects of specifying multiple objective functions on the solution of optimizing models. They argue that this provides useful information about the production possibility frontier of the economy, and about the trade-offs between different policy objectives. Following this argument, Wijesinghe (1983), presents a review of the methods used to evaluate multiple objective functions.

[10] Loucks (1975, p.214), lists some of the possible objective functions that have been suggested for development planning, and its typical units of measurement.

[11] The construction of such a function is difficult or indeed impossible if one accepts Arrow's axioms for social choice and individual values. For practical purposes, however, the researcher has to use cardinal measures. As Manne (1974) comments: "Typically, a development planner earns his living by ignoring the axiom of 'nondictatorship' and by devising plausible measures to quantify the collective goals of his society. For practical purposes, the planner is prepared to measure these preferences in cardinal form, eg. consumption, or perhaps utility". To understand why it has taken so long for cardinalism to be accepted by ordinally trained economists, and the usefulness of cardinalism for assessing uncertainty,

The objective function in this model consists in maximizing the discounted present value of the sum of aggregate consumption along the model's plan horizon, which is the most common and easily interpretable maximand [12], subject to terminal net wealth. Since the time horizon of the model is finite, a necessary condition for any finite-horizon plan to be optimal is that it requires the imposition of terminal conditions on national economic resources because, otherwise, the model would devote all resources to consumption (i.e. bang-bang solution) (see Heal, 1973). As already stated, in the context of the Mexican economy, national wealth can be decomposed into three types of assets: capital stocks, oil and gas underground, and foreign debt.

Before describing the exact way in which the objective function is defined, it is important to recognize that since truncation of the policy time horizon is somewhat arbitrary, and that there is no explicit analysis of what is to happen after the terminal year of the model, there is no perfect way to model the terminal conditions problem without introducing distortions (see Blitzer et al., 1975 pp.105-109) [13].

---

intertemporal choice, income distribution, etc, see Chakravarty (1969) and Manne (1974).

[12] Consumption is a plausible choice of the maximand for several reasons. For example, it is possible to trace out the transformation surface of the economy by varying consumption weights, and it also allows to capture changes in the standard of living of the population. For a further analysis of the advantages of using consumption as a proxy to the social welfare function, see Loucks, op.cit.

[13] (B-E), for example, introduced as a constraint a minimum level for terminal year investment based on the sum of investment

Nonetheless, it is widely accepted that attaching explicit and exogenous prices to terminal-year assets and adding their value in the maximand, represents the simplest and purest presentation of the dual equations and shadow prices, provided that the terminal-year prices are plausible (see Dervis et al. op.cit p.87). Therefore, in order to reduce the instability of the shadow prices and to secure adequate investment in the terminal year of the model to support future post-terminal growth, the terminal value of the three assets are introduced in the objective function. At the same time, by ignoring the results of periods close to the terminal year (2008), it is possible to diminish the necessarily arbitrary influence terminal conditions will always have on the solution of the model [14].

In short, what is maximized is the sum of aggregate consumption in each period properly discounted, plus the discounted value of both capital stocks and oil and gas reserves left over at the end of the planning period, less the value of foreign debt inherited post-terminally and discounted at a rate i. There is, then, a penalty for the level of accumulated foreign debt, and a premium for the levels of capital stocks and hydrocarbon reserves, which exist at the end of the last period. The

---

undertaken previously. Their results showed instability of the shadow prices for some periods. This was caused, according to the authors, by the unsatisfactory terminal conditions specification of their model.

[14] Blitzer et al., op.cit., chapter III (appendix); and Dervis et al., op.cit., chapter 3, provide a good review about the different ways to tackle this problem.

calculation of these amounts was described previously in the sub-sections dealing with foreign borrowing, capital capacity constraints and oil reserves [15].

$$\text{Max} \sum_{t=1}^{6} C_t + \sum_{i=1}^{13} \overline{PK}_{i,7}\, K_{i,7} + qr\, R_7 - qd\, D_7$$

where:

C_t = Present value of aggregate consumption, year t.
$\overline{PK}_{i,7}$ = Discounted terminal year capital stock price in sector i.
$K_{i,7}$ = Terminal year capital stock in sector i.
qr = Discounted terminal year price of one million barrels of oil and gas reserves.
R_7 = Oil and gas reserves in year 2008.
qd = Discounted terminal year price of one billion 1980 pesos of foreign debt.
D_7 = Accumulated foreign debt in year 2008.

Viewing the objective function in another way, it aims to determine the rate of capital accumulation and, concomitantly, the proportion of national wealth to be withheld from current consumption in order to build up that in the future. This is what any optimal finite-horizon plan should aim at according to Heal, op.cit. [16].

In summary, sixteen sets of equations describe the intertemporal, multi-sectorial optimizing model used in this study. The model has a standard I-O structure in the sense that commodities are required as inputs in production as well as for final demand. It also incorporates, however, special features to reflect

[15] Recall that section 4.2 described the price-sensitive ELES which is used to incorporate substitution possibilities between consumption expenditures.
[16] For an analysis of the characteristics of optimal plans see Heal (op.cit, chs. 10-12).

important aspects of reality that were necessary according to the purpose of the analysis. Particularly, in comparison with earlier models of this kind, including (B-E), the present model contains truly price-sensitive endogenous choices by virtue of several non-linear functions, which together with the rest of the equations, are optimal by the standards of the objective function. The objective function too, differs from previous studies and it satisfies the necessary and sufficient conditions of optimal finite-horizon problems such as the convexity of the consumption set and the specification of terminal constraints on national economic resources (see Heal, op.cit.).

Appendix A describes the way in which the exogenous variables and the parameters of the different equations of the model are estimated, with the exception of certain policy variable instruments whose estimation is explained in section 6.1. Meanwhile, the next section examines the software package employed to solve the optimizing model.

5.3 The Solution Algorithm.

GE models have come a long way from the early static Leontief's I-O work. Throughout their development, there has always been a tension between empirical practice and available theory. In the beginning empirical model builders ran into problems with programming models for a number of reasons. First, the size and complexity of models was severely limited by technical and budgetary constraints, so that models remained very small.

Second, all early models used linear programming which is prone to corner solutions, extreme specialization, and on top of that, it also lacks price-induced substitution possibilities. Modelers then imposed various ad hoc bounds on production, consumption, and other activities in order to achieve realistic behaviour, but which resulted in distortions in the shadow price system and above all, could not be justified as additional system constraints [17].

The piece-wise linear approximations method (see Duloy and Hazel, 1975), came into widespread use during the period when linear programming was the only practical method available for the computation of large-scale systems. This method was used by (B-E) for solving their model and, as already stated, basically consists in approximating nonlinear equations, say, the C-D production functions, by prespecifying an arbitrary number of combinations of capital and labour inputs per unit of output. By prespecifying the substitution activities in this way, there are several difficulties: (a) there is flip-flop behaviour if too few activities are selected -that is, small price variations can lead to large changes in quantities; and (b) because of the exponential increase in the number of possible combinations, it becomes awkward to handle simultaneous

[17] Taylor (1975) carried out a general survey of GE models and concluded that such problems were very common.

substitution between three or more inputs in this way [18].

Fortunately, nowadays, with the rapid evolution in terms of nonlinear programming algorithms, the gap between the development of new theoretical models and the ability to implement them empirically has narrowed considerably [19]. Indeed, numerical optimization methods are now capable of handling a sizable number of price-sensitive nonlinear relationships, both in the objective function and in the restrictions, liberating, to some extent, the empirical model builder from the straight-jacket of linearity or recursiveness.

Perhaps the best example of the progress achieved in numerical optimization methods is the General Algebraic Modeling System (GAMS), which was conceived at the World Bank during the early 1980's. This system has automated most stages in the modeling process, thus making modeling quicker, cheaper, and less demanding of specialized skills, while reducing the likelihood of errors. Moreover, compared with other languages, GAMS has a very strong expressive power, allowing compact representations of complex relationships. Also, because the syntax of GAMS closely resembles standard algebraic notation, the

[18] For a further discussion of the problems with piece-wise approximations see Preckel (1985), who also compares other alternative algorithms for computing economic equilibria.
[19] The real cost of raw computing power measured in multiplication per dollar has nearly halved every year over the last two decades, In addition, massive research and development efforts in the design and implementation of algorithms have reached impressive levels of reliability and efficiency. See Meeraus, 1983.

system facilitates the communication of model assumptions and results [20].

Hercules, a software package developed by Arne Drud and a subsystem of GAMS, is a SAM-based modeling system where all the input requirements discussed in chapter V constitute its basis. Some of the advantages that the SAM-TV approach represents for macro-modeling are, therefore, now supported by Hercules.

Furthermore, GAMS can also solve other major groups of problem classes, namely: linear programmes, nonlinear programmes and mixed integer programmes (i.e linear programmes that include some variables which can only take on integer values). The GAMS system uses problem size and structure information to select a code that is well suited for the problem. For example, one of the programming codes that is associated with GAMS is MINOS. This algorithm was developed by Murtagh and Saunders and has been integrated into GAMS. Other examples of packages used with GAMS are GRG2 designed by Leon Lasdon and CONOPT developed by Arne Drud. All three of these codes are for nonlinear programming problems but can also be used to solve linear programming problems [21].

Given that the present model contains some nonlinear equations, and because of its size: 742 constraint rows,

[20] For an extensive description of GAMS, see Meeraus (1983), and Kendrick and Meeraus (1985).

[21] It is also possible to override the Gams' choice of code and select a particular algorithm associated with the system. Experience has shown, however, that GRG2 has a comparative advantage for small problems up to seventy constraints, while CONOPT and MINOS are better suited for larger problems.

919 activity columns, 3872 non-zero elements in the constraint matrix, and 903 nonlinear variables, GAMS chose MINOS version 5.0 as the appropriate nonlinear programming package to solve it. At this size, numerical optimization was not a bottleneck and an optimal solution was found [22].

One of the main advantages of MINOS is that it eliminates the need to employ the piece-wise approximations method used by (B-E), by virtue of allowing the introduction of nonlinear equations, such as the C-D production functions and the ELES discussed in section 4.2, directly into the model. This is so provided that the nonlinear equations are convex, and that plausible initial values for their endogenous variables (e.g. the demands for sector-specific capital and the three labour categories in the C-D production functions) are specified so as to help the algorithm to find an optimal solution [23]. In this respect, and regarding this work, a LP version of the model was solved initially, that is, instead of specifying C-D production functions to generate value added, the demands for capital and labour were calculated, in this first step, through a fixed coefficients technology. Similarly, instead of using nonlinear ELES, private consumption was

[22] Because of its size the model could not be solved on a PC. It was run in an IBM 4381 and the optimal solution took 1534.6 resource usage units and 4688 iterations to converge. For reasons that will later be explained, the nonlinear programming model was solved using as starting point the solution obtained with a linear programming version of it.
[23] The default values for these variables are zero, clearly then, MINOS requires a much better starting solution than that.

originally estimated through three linear equations [24]. The resulting size of the linear programming matrix was: 819 rows and 819 columns with 3460 non-zero elements.

Once an optimal solution was found for this simplified LP model, the values of the endogenous variables were used as starting points in the search for the solution of the complete nonlinear model. This, in turn, meant a big saving in terms of both the resource usage units and the number of iterations needed to find the optimal solution [25].

Optimal solution of the model was achieved whenever the parameters were in the range where the behaviour of the dynamic system underlying the nonlinear programming model was stable. On non-stable paths, convergence of the algorithm failed to occur in some instances. The computer printout of the representation and solution of the base run of the model is presented in Appendix B.

In sum, GAMS and in particular MINOS 5.0 allows to solve relatively large economy-wide models (in terms of the degree of disaggregation of accounts, time periods considered, etc), introduce nonlinear equations directly into a model, and above all, is apt to provide a more precise solution than most of the algorithms that exist nowadays, including the grid approximation used by (B-E). It should also be emphasized, however, that MINOS cannot

---

[24] The three linear consumption equations were given by upper and lower bounds on private consumption, and an equation which calculated total consumption for the 1984-2004 period.
[25] This procedure was possible because GAMS allows to solve various versions of a model, linking their solutions.

in general reach exact optimal solutions. Rather the algorithm stops at an approximate optimal solution where the reduced gradient is null up to some very small tolerance.

This software and some others, shows the need to maintain the dialogue between those who formulate theoretical models and those who provide the algorithms required for their solution [26]. By doing so, the gap between the development of new theoretical models and the ability to implement them empirically will narrow even further. The next chapter reports the base run solution of the model obtained with MINOS version 5.0.

[26] Arne Drud, for example, has not only designed Hercules and CONOPT, but he has also been involved in the development of economy-wide models.

CHAPTER VI.

BASE RUN RESULTS OF THE MODEL.

This chapter reports the results obtained with the base run of the model described in chapters IV and V. The chapter is composed of four sections. Section 6.1 examines the assumptions made with respect to the values of certain exogenous variables which can be used as policy instruments in alternative scenarios. Prior to the discussion of the results, section 6.2 explains some general features of the model. Section 6.3 then describes the primal solution of the model's base case, that is, its major macroeconomic features as well as its sectorial output patterns. Finally, the dual solution or shadow prices associated with the model's constraints are analyzed in section 6.4.

6.1 Policy Variable Estimates.

Appendix A describes the way in which all the data base of the model was obtained, with the exception of certain exogenous variables which can be used as policy instruments, and whose estimation is explained next.

The first set of non-parameter estimates corresponds to the two exogenous variables of the material balance equation (see section 4.2): government expenditure ($\bar{G}_{i,t}$), and exogenous exports ($E_{i,t}$). The former is forecast on the basis of the historical growth rate applied to the initial vector of government consumption obtained from the 1980 I-O table. The growth rate was calculated using Banco de Mexico's statistics for the 1982-86 period. This rate, about 2 percent per year in real terms, is also assumed to hold throughout in the base run of the model. The resulting vector of government expenditure for the 1984-2004 horizon is the following:

Government Expenditure, 1984-2004.
(1980 Billions of Pesos)

Year	$\bar{G}_{i,t}$
1980[1]	448.744
1984	484.644
1988	523.416
1992	565.290
1996	610.514
2000	659.355
2004	712.105

[1] Obtained from 1980 I-O Table, (SPP, 1986).

A similar procedure was employed to calculate the values for the exogenously specified export sectors. In this case the relevant growth rates were obtained for the 1982-87 period, also using Banco de Mexico's statistics. On average, the real rate of growth of all exogenous exports is about 2 percent per year during the 1988-2004 period.

Exogenous Exports, 1980-2004.
(1980 Billions of Pesos)

Year	Agric.	Mining	Refin.	Petro.	Trans.	Comm.	Total
1980[1]	13.4	21.7	9.0	2.9	21.7	32.7	101.4
1984	14.5	23.5	9.7	3.3	23.4	35.3	109.4
1988	15.6	25.3	10.5	3.6	25.3	38.1	118.4
1992	16.9	27.4	11.4	3.9	27.3	41.2	128.1
1996	18.2	29.5	12.3	4.2	29.5	44.5	138.2
2000	19.7	31.9	13.2	4.5	31.9	48.0	149.2
2004	21.3	34.5	14.3	4.9	34.4	51.9	161.3

[1] Obtained from 1980 I-O Table (SPP, 1986).

The second set of non-parameter estimates refers to the three linear equations that determine oil and gas reserves and extraction levels (described in section 5.2). The first of these equations requires the initial endowment of hydrocarbons reserves. In 1988, oil and gas reserves (proven) were estimated at 71,750 millions of barrels (mb). The second equation, on the other hand, needs the 1980 q parameter in order to convert oil gross output in billions of pesos into oil extraction in millions of barrels (mb). This value is 3.5567 according to Pemex (1984).

As has been previously noted, the model assumes an upper bound on the extraction levels of hydrocarbons ($\overline{\overline{EXT}}$). It is assumed that from 1988 onwards oil and gas production ceilings will increase slightly compared to the 1988 level, which had been lowered relative to that in 1984. $\overline{\overline{EXT}}$ is reported next:

Oil and Gas Production
Ceilings, 1984-2004.
(Millions of Barrels)

Year	$\overline{\overline{EXT}}_t$
1984*	1393.0
1988*	1256.2
1992	1396.9
1996	1551.5
2000	1675.6
2004	1776.1

* Observed values.

Finally, the endogenous decision of how much to borrow and/or repay in each time period is calculated on the basis of the exogenously given 1980 level of accumulated total foreign debt ($\bar{D}_0$), expressed in billions of pesos. In that year, total foreign debt amounted to $43,519 millions which at the official exchange rate corresponds to 1012.1 billions of pesos (SHCP, 1986 p.14). Similarly, it is estimated that from 1980 to 1984 total net foreign borrowing (private and public) was equivalent to 1234.1 billions of pesos at the 1980 exchange rate.

On the other hand, the debt-servicing equation requires the real interest rate on foreign debt (r). The Financial Programme (Programa Operativo Anual de Financiamiento) elaborated by the Ministry of Finance of Mexico assumes world interest rates (a weighted average of Libor and Prima Rate) constant at an average of 8 percent over the period 1988-91. This figure is assumed to hold constant for the whole planning horizon in the base run.

Table 6.1 summarizes the assumptions made regarding the various exogenous variables of the model in its base case scenario.

Table 6.1
Exogenous Variable Estimates for the Base Case Scenario

Price of Crude Oil Exports:	1980-1988 observed figures. 2.0 % real annual growth 1988-2008.
Price of Manuf. Goods Exports:	1980-1988 observed figures. 1.0 % real annual growth 1988-2004.
Price of Agric. Imports:	1980-1988 observed figures. 1.0 % real annual growth 1988-2004.
Price of Mining Imports:	1980-1988 observed figures. 1.0 % real annual growth 1988-2004.
Price of Refining Imports:	1980-1988 observed figures. 1.0 % real annual growth 1988-2004.
Price of Manuf. Imports	1980-1988 observed figures. 2.0 % real annual growth 1988-2004.
Maximum Oil and Gas Extraction Levels:	1980-1988 observed figures. 2.8 % annual growth 1988-1992. 2.8 % annual growth 1992-1996. 2.0 % annual growth 1996-2000. 2.0 % annual growth 2000-2004.
Oil and Gas Reserves:	1980-1988 observed figures. No new discoveries: 1988-2008.
Exogenous Exports Sectors:	1980-88 observed figures. 2.0 % avg. real annual growth 1988-2004.
Government Expend.	2.0 % real annual growth 1980-2004.
Population Growth	2.3 % per year on average 1980-2004.
Rural Labour Growth	3.6 % per year on average 1980-2004.
U. Unskilled Labour	3.8 % per year on average 1980-2004.
U. Skilled Labour	3.4 % per year on average 1980-2004.
Debt Real Int. Rate	8.0 % throughout.
Consum'n Disc. Rate	10.0 % throughout.

An attempt has been made, whenever possible, to approximate the data base for the base run of the model to recent conditions of the Mexican economy. This, of course, does not imply that the solution for this case should be expected to replicate exactly those same conditions, for reasons already noted, and some others to be discussed next.

6.2 General Features of an Optimizing GE Model.

Before discussing the results, there are several features of an optimizing model one must be aware of, as in addition to the terminal conditions problem, they influence its results.

To begin with, the model is normative in nature, so that the solutions cannot be taken as forecasts [1]. Secondly, an optimizing model accepts all pricing and other conventions which are used and are implicit in the national income accounts and I-O table which provide much of the data base for the model. In this case, the model's unit is constant 1980 billions of pesos [2].

Thirdly, the behaviour of the variables within periods is supposed to be smooth, which implies, for example, that the values for 1988 should be interpreted as those that would produce an optimal path until 1988, rather than reflecting short-run contingencies that affected the economy in that year.

Fourthly, all the features of the solutions are the result of a comprehensive view of the entire period over which the model is solved. The first and the last periods (and all the periods in between), are fully taken into account. To put it differently, the contributions of each period's activity to the objective function and the

[1] At best one can say that the solution is the equilibrium that would be obtained under perfect markets.
[2] This is particularly relevant when looking at the foreign accounts where variables must be interpreted in real terms and exclude the effects of the dollar inflation.

requirements for that level of activity in each period are evaluated simultaneously, and then are incorporated in the solution [3].

Fifthly, the solutions are the result of the adjustments made by the optimizing process of the model so as to maximize the objective function, subject to constraints and without mistakes. This can be rationalized by the assumption that there are perfectly competitive markets throughout the economy or that there is perfect planning [4].

Sixthly, technological change, learning-by-doing and other sources of productivity change which always have a role in a real-world development process are neglected.

Finally, the model is real in the sense that it contains no financial markets (i.e. money plays a neutral role), and does not predict either domestic or international inflation. However, it does give some clues as to the ratio between the two as shall be discussed later on.

Overall, from these general characteristics it is difficult to judge the balance of error which will exist in the model solutions. On the one hand, the solutions will represent, in many ways, an over-optimistic view of

---

[3] To the extent that the model is a deterministic representation of a world which is actually stochastic, the solutions can only be interpreted in a rational expectations framework.

[4] Theoretically, optimization models offer the best solution to rational decision-making in economic planning. Indeed, it can be said that the optimal solution to a given problem within constraints can only be given by this approach.

the Mexican economy and its adjustments over time in the development process. On the other hand, there are some sources of underestimation in the model's projections of potential growth.

Probably, it could be said that the results in the early periods will represent a somewhat too optimistic view of the outcomes of the adjustments which would actually be made in the economy of Mexico approximated by the specifications of the model and data. That is because in a typical solution, there are relatively significant rearrengments made in the early years of output, levels of investment, and other allocations of resources. On the other hand, technological changes are likely to be relatively less important in earlier periods than in later periods. With all these features in mind, the following section reports some of the main primal or real results obtained with the model's base run.

6.3 Primal Results.

Table 6.2 summarizes the major macroeconomic features obtained with the model's base run solution.

Table 6.2
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3403.4	3839.1	4417.2	5059.5	5469.6	5797.0	2.9
Investment*	1207.6	1394.1	1180.2	1203.8	1389.8	1422.0	1634.1	1.3
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.7	187.5	203.6	225.2	235.9	287.9	1.0
% Tot.Exp.	54.4	48.5	22.3	18.4	15.5	14.7	15.9	
Manuf. Exp.	89.2	163.8	533.4	773.3	1090.2	1214.8	1358.6	12.0
% Tot,Exp.	21.4	30.9	63.6	70.0	75.0	75.9	75.2	
Other Exports*	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	14.1	11.6	9.5	9.3	8.9	
Total Exports	418.2	530.9	839.3	1105.0	1453.6	1599.9	1807.8	6.3
Total Imports	528.1	1084.9	1192.9	1221.0	1215.0	1163.7	1413.3	4.2
Trade Deficit	90.9	554.0	353.6	116.0	-238.6	-436.2	-394.5	
GDP	4470.1	4728.1	5189.1	6070.3	7298.4	7987.2	8537.7	2.7
Foreign Bor.	-	1234.1*	-261.6	-181.0	-167.2	-148.1	-151.0	
Acc.For.Debt	1012.1	2246.2	1984.6	1803.6	1636.4	1488.3	1337.2	
% GDP	22.6	47.5	38.2	29.7	22.4	18.6	15.7	
Interest Pay.	81.0	179.7	158.7	144.2	130.9	119.0	106.9	
% Tot.Exp.	19.4	33.9	18.9	13.0	9.0	7.4	5.9	
% GDP	1.8	3.8	3.1	2.4	1.8	1.5	1.3	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

The average annual growth rate of GDP from 1980, the pre-plan year, to 2004 is 2.7 percent, a rate well below the 8 percent target specified in the National Plan of Industrial Development (see section 1.4), and also below the current labour force growth (estimated at 3.6 percent) [5].

External Debt:

The most striking part of this result is that the Mexican economy grows despite the fact that no new foreign borrowing is contracted during the 1984-2008 period. As indicated in section 2.3, the large run up in external

[5] The growth of the economy during the 24 years considered in the model is also well below the 6.5 percent of annual growth achieved by the Mexican economy over the 1960-1982 period.

debt is concentrated in 1981 and 1982 and, by 1984, Mexico had more than doubled its 1980 total debt level. This is shown by the share of accumulated foreign debt to GDP which jumped from 22.6 percent in 1980 to 47.5 percent in 1984 [6]. Given the domestic parameters employed in the base solution, including the terminal condition penalty imposed on total external debt, the system is not capable of using foreign resources so productively as to make it worthwhile to borrow (i.e. increase the value of the maximand).

In other words, taking all possible information, in particular, the economy's present and foreseeable ability to pay, the model considers that by 1984 Mexico was over indebted, that is, total accumulated external debt was excessive [7]. Thus, it is clear that the optimal decision for the economy is to reduce its burden provided, of course, that it is a feasible solution for the system as a whole. Comparing the shadow value of foreign exchange, the marginal interest costs, and marginal returns on domestic assets, the model makes

[6] Note that the 1980 and 1984 debt figures are exogenous corresponding to the observed values. For subsequent years, however, the model decides how much to borrow and at the same time there is provision for interest payments and repayment or rolling over of past foreign borrowing either before or after the model's time horizon.
[7] There is no common agreement regarding the point at which a certain level of debt becomes excessive but, certainly, it is clear that foreign creditors have considered Mexico's indebtedness as excessive, in so far as they have refused to voluntarily give the country new external loans so that the economy could keep its present level of debt in real terms. Mexican authorities, on the other hand, have also acknowledged such a situation as they have been trying to reduce the burden of debt by means of several mechanisms, as explained in section 2.3. Moreover, the significant discounts offered at the secondary markets for Mexican debt seem to support this idea too.

principal repayments which amount to 909.0 billions of pesos over the 1984-2004 period, that is, 40.5 percent of the total debt accumulated by 1984 [8]. Accordingly, the proportion of total debt to GDP falls continuously (see Table 6.2), although it is not until the year 1996 that this fraction is inferior to its base year share.

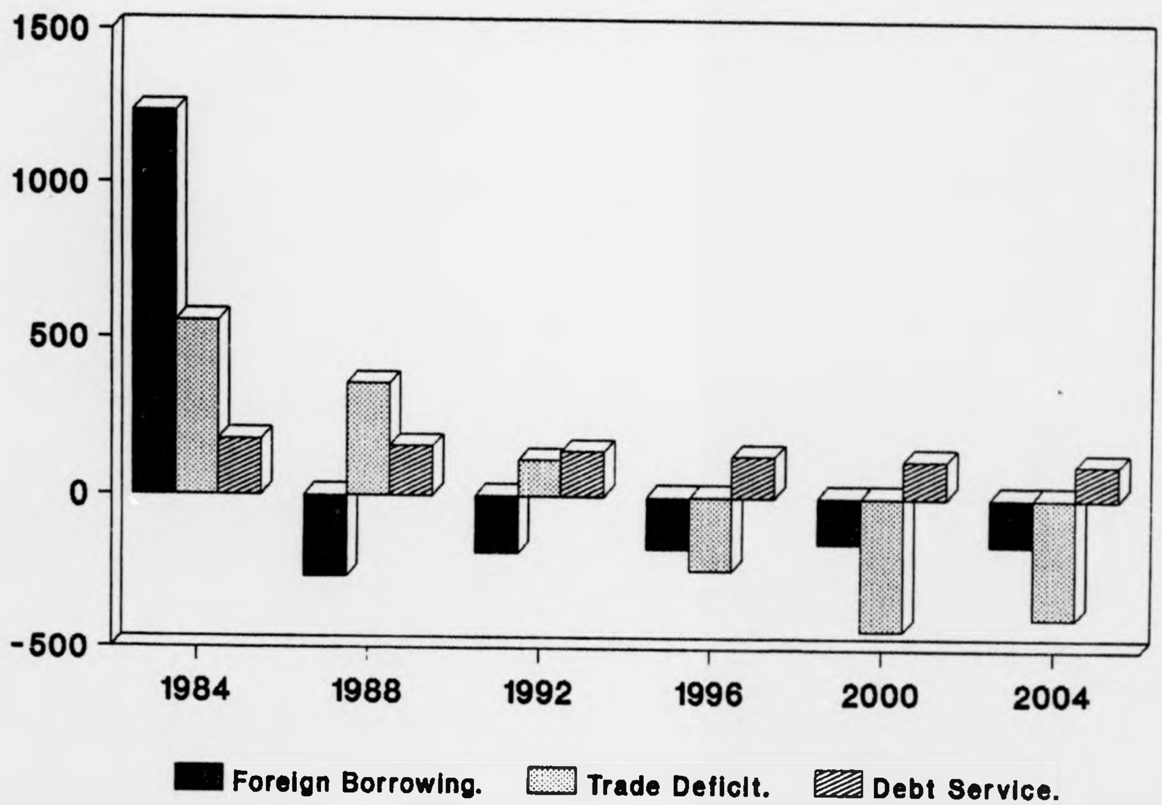
The level of external debt that remains at the end of the planning period, 1337.2 billions of pesos, is rolled over after the model's time horizon as a terminal condition penalty on the objective function. It is also important to single out from this result, the intertemporal preferences of the system in terms of principal payments. Optimal foreign borrowing throughout the model's planning horizon can be seen in Figure 6.1. The model decides to repay more debt during earlier periods (1988-92) in order to reduce the burden of debt quickly, providing with it a breathing space for economic growth, while at the same time adjusting to the economy's payment capacity. From 1992 onwards, principal payments basically stabilize.

As Figure 6.1 shows, too, the cost of external borrowing also calls for a reduction in the trade deficit which is gradually reversed over time. In effect, the optimal path for the base solution of the model indicates that the increasing loss in external aid leads to a lower trade deficit in the first three periods, and to surplus

[8] This and the following results depend crucially on the objective function and the base run assumptions. Sensitivity analysis, therefore, are carried out in chapter VII to evaluate the optimal responses of this model to variations in certain parameters.

Figure 6.1

Optimal Debt Payments and Trade Deficit.
(Billions of Pesos)



thereafter. This transition implies, as shall be discussed later, an expansion in both export and import-substituting activities.

As a result of the amount of foreign debt accumulated over the 1980-84 period, the burden of debt service is greater in those years: interest payments representing about a third of total exports in 1984. Thereafter, debt service payments fall continuously as the level of total debt decreases over time (see Table 6.2 and Figure 6.1). Hence, taking both effects into consideration: principal and interest payments, there is a net transfer of resources from Mexico to its foreign creditors of 1569.1 billions of pesos during the 1984-2004 period, equivalent to over half of government spending or 4.8 percent of GDP on average in the same period [9]. Yet this latter figure is not as high as the observed net transfer of resources which occurred over the last five years, estimated at 5.5 percent of GDP on average (see section 2.3).

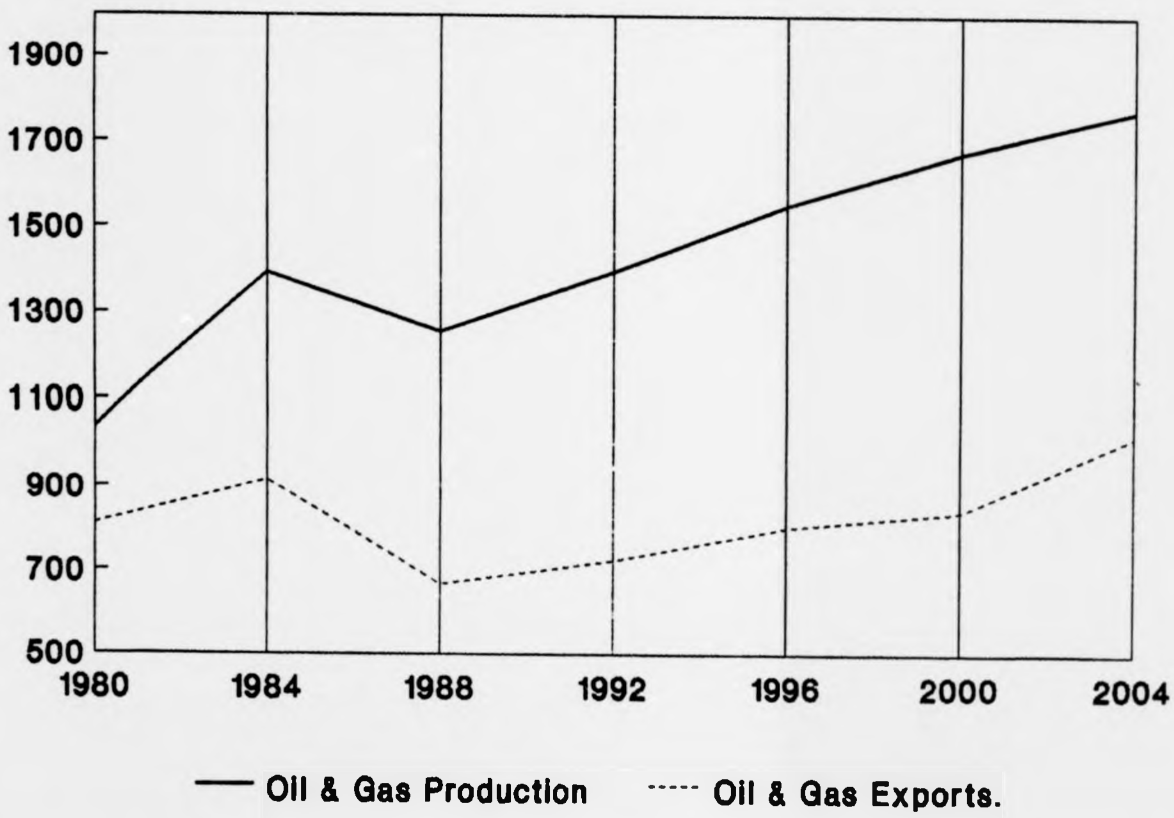
Oil Extraction and Reserves:

It will be recalled, on the other hand, that in addition to the terminal condition premium for the level of oil and gas reserves, in this model there is an upper bound placed on production of crude oil and gas, and the optimizing process then chooses any level up to the maximum. As can be seen in Table 6.3 and Figure 6.2, the

[9] Recall that the interest payments correspond to a fixed real interest rate on foreign debt of 8 percent assumed throughout the model's base run horizon. The estimated rate for 1989, however, was about 10 percent, according to figures published by Banco de Mexico.

Figure 6.2

Optimal Oil and Gas Production & Exports
(Millions of Barrels)



optimal solution actually sets crude production at the maximum levels throughout and, consequently, oil exports are constrained by these upper bounds.

Table 6.3
Optimal and Maximum Oil and Gas
Extraction and Reserve Levels, 1984-2004.
(Millions of Barrels)

	Extraction Levels:		
Year	Optimal	Maximum	Reserves
1984*	1393.0	1393.0	71750.0
1988*	1256.2	1256.2	71750.0
1992	1396.0	1396.0	66725.2
1996	1551.5	1551.5	61141.2
2000	1675.6	1675.6	54935.2
2004	1776.1	1776.1	48232.8

* Observed figures.

Clearly, then, additional exports of oil would have been made over the model's time horizon if the upper boundary constraint on oil production had not been imposed. In turn, foreign borrowing might have been less. This result, then, also seems to suggest that Mexico's decision to help 'stabilize' the world oil market by imposing ceiling on production and exports has been costly in terms of growth prospects, and reduction of the trade deficit and foreign indebtedness [10].

Undoubtedly, there are some physical constraints relevant to the oil depletion decision, yet they are not currently binding, and on top of that, oil reserves do not appear to be a constraint in spite of the fact that

[10] It has to be said, however, that any attempt by Mexico to increase its share in the world oil supply is limited, and might well worsen the prospects of the international price of oil. This issue shall be discussed in more detail in section 7.3.

no new discoveries are incorporated into the model from 1988 onwards [11]. As depicted in Figure 6.3, given the current rate of oil extraction and available reserves, by the year 2004, Mexico would still have hydrocarbon reserves for about 27 years.

Industrialization:

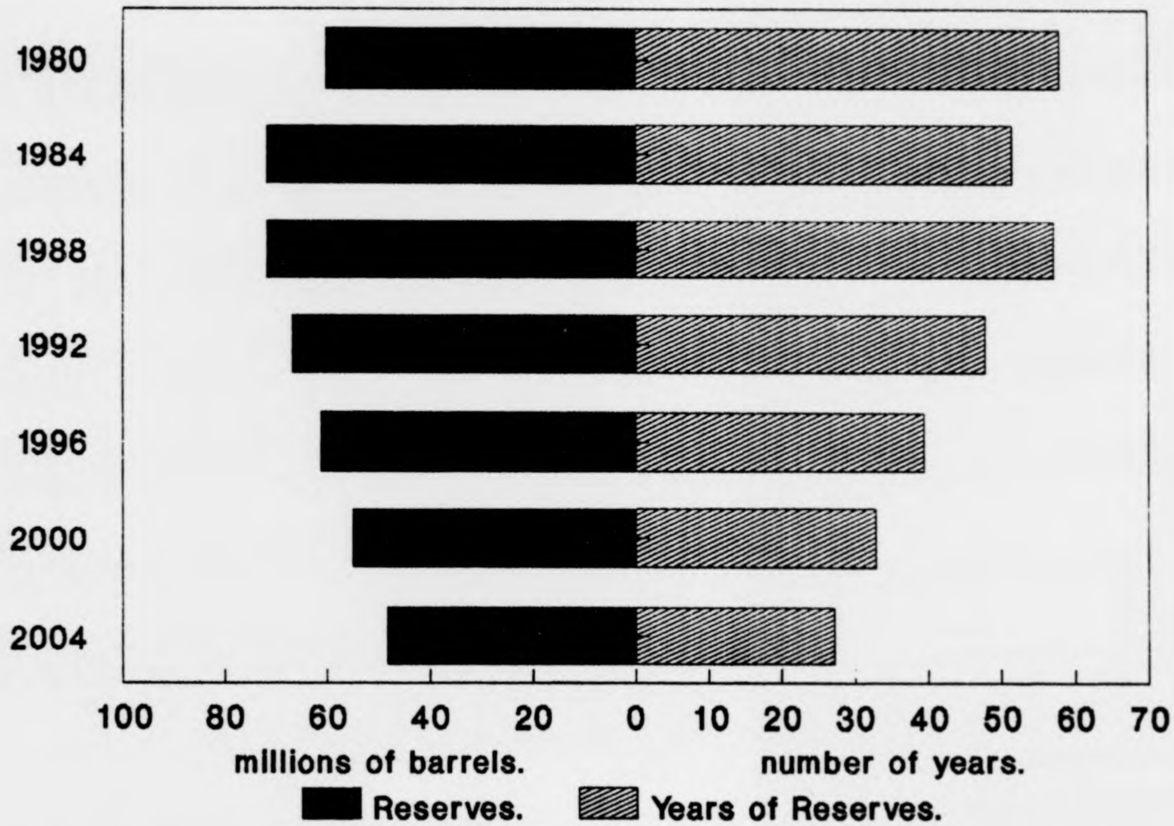
Because of the upper boundaries on oil extraction levels and given that there is no new external aid, it is clear then that the only flexibility in terms of getting the foreign exchange revenues that the Mexican economy needs according to this model, lies in the behaviour of the other two endogenous exports sectors: capital goods and the rest of manufacturing (the remaining exports are imposed exogenously to the model using recent historical values). The results of Table 6.2 show an impressive performance of manufacturing exports, which grow at an annual average of 12.0 percent throughout and, consequently, they become the main source of external resources for the system. These resources helped the economy to reduce the trade deficit as well as to finance the country's external commitments.

The base run of the model indicates, therefore, that in order for the Mexican economy to grow, given the assumptions regarding the pattern of world oil prices, interest rates, and so on, it will choose strong non-oil export growth. In particular, this transition relies, to

[11] It is also important to bear in mind that optimal oil production is set at the maximum possible levels in spite of the objective function's terminal condition premium for oil and gas reserves.

Figure 6.3

Hydrocarbons Reserves.



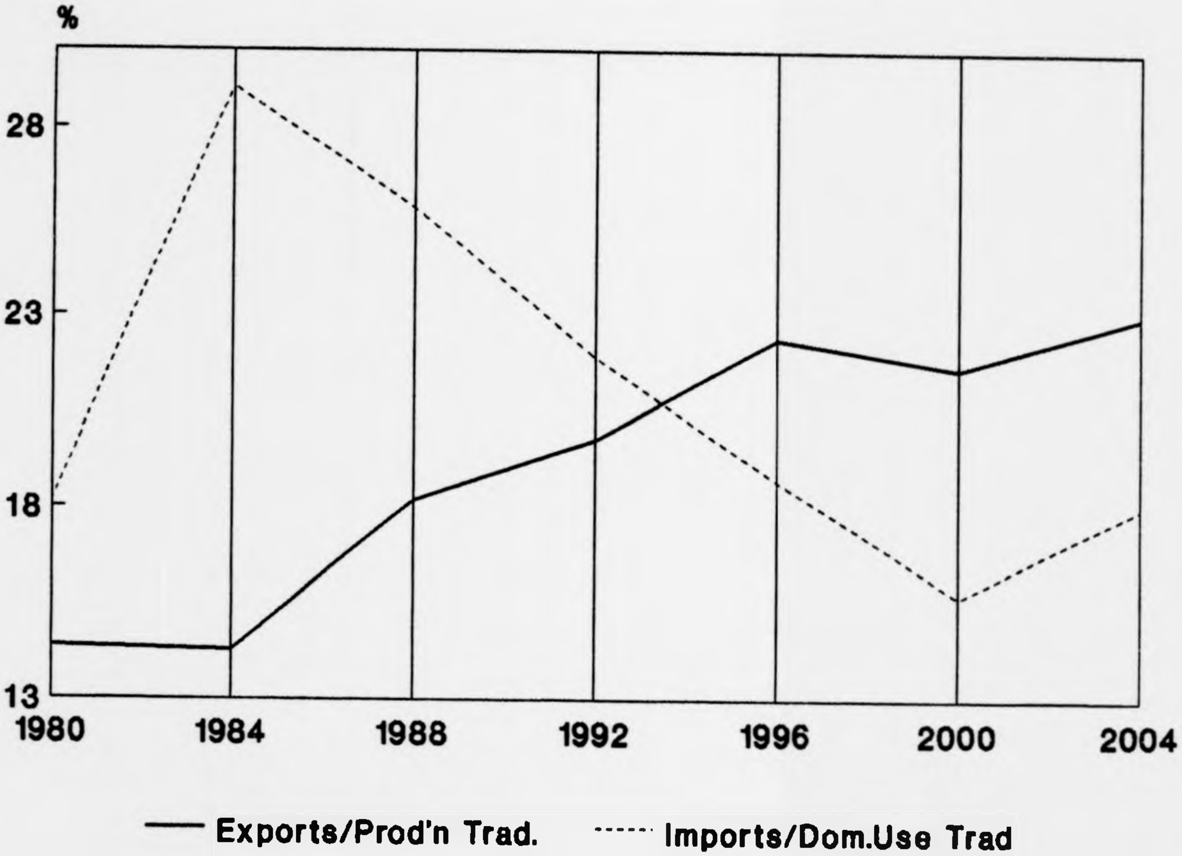
Years = Reserves/Extraction.

a great extent, on manufacturing exports rapidly becoming an increasingly important source of foreign currency. As mentioned in section 2.1, and as shown by the model's results, manufacturing exports are apt to be successful in a country such as Mexico because, among other things, they constitute a dynamic force in stimulating economic growth: manufacturing industries represent one of the main sources of investment goods which, in turn, help to raise productivity, employment and income throughout the economy. Hence, this result supports the government's decision to increase both the efficiency and the exposure of domestic industry to international markets. On the other hand, it is important to recognize that the model solution of the base case suggests the possibility of a relatively easy adjustment to major changes in the availability of foreign funds. This may well overstate the ease of such a transition even allowing for the abstraction in the model from influences such as capital flight, which have dominated Mexican finances in the present decade.

Export Expansion and Import Substitution:

Figure 6.4 shows the adjustment in terms of export expansion and import substitution which is needed on the base case optimal growth path because of the abrupt change in foreign exchange receipts described above. Under base case assumptions, total real annual export growth would average 6.1 percent from 1980-84, 12.1 percent from 1984 to 1988, and then decline gradually to

Figure 6.4 **Export Expansion and Import Substitution**



7.1 percent from 1988-1992 and 1992-1996, and 3.1 percent at the end of the planning horizon. The share of exports in domestic production of tradeable commodities [12] would rise from 14.3 percent in 1984 to 23.0 percent at the end of the year 2004. While this is a large increase over a relatively short period of time, it would bring Mexico's share of exports in tradeable output to a level slightly below the average 25-30 percent characterizing most semi-industrialized economies (see Dervis et al., 1984). Nonetheless, as already mentioned, given the limitations constraining the oil sector, such an increase requires sustained and very rapid growth in manufactured exports over a period of 20 years. As depicted in Figure 6.4, parallel to the process of export expansion, the share of imports in domestic intermediate and final consumption would have to decline from about 30 percent in the early 1980's to 18 percent at the end of the model's horizon [13].

Sectorial Output:

Following the theoretical model discussed in section 3.2, the 13 sectors identified in this work for the Mexican economy can be grouped into three broad sectors: (i) tradeables, (ii) non-tradeables, and (iii) oil related sectors. The grouping of the sectors is presented in Table 6.4:

[12] Tradeable sectors are listed in Table 6.4 (see next page).
[13] Later on the opportunities for import substitution that exist in this model shall be analyzed.

Table 6.4
Tradeable, Non-tradeable and Oil Sectors.

1. Tradeables:	2. Non-Tradeables:	3. Oil:
(a) Agriculture	(a) Construction	(a) Oil + Gas
(b) Mining	(b) Electricity	(b) Refining
(c) Manuf. Capital	(c) Transport	(c) Petroche-micals.
(d) Manuf. Rest	(d) Commerce	
	(e) Services	
	(f) Government	

The processes of export expansion and import substitution amount to a substantial increase in the share of the tradeables producing sector in the economy. Figure 6.5 describes the base case results in terms of the share of the tradeable sector has in the capital stock, employment and output in the domestic economy. All these shares increase about 10 points during the planning period. By contrast, the share of the aggregate non-tradeable sector declines by approximately the same amount in terms of capital and 8 and 7 points with respect to output and labour, respectively (see Figure 6.6). The structural adjustment implicit in those Figures is necessary to allow the required degree of export expansion and import substitution. Such adjustment can also be described in terms of growth rates. First individual sectorial performances are analyzed and then, broad sectorial patterns are discussed. Tables 6.5 and 6.6 show the growth of gross output in each sector for each time period, and their shares in total output, respectively.

Figure 6.5

Share of Tradeables in Domestic Economy.

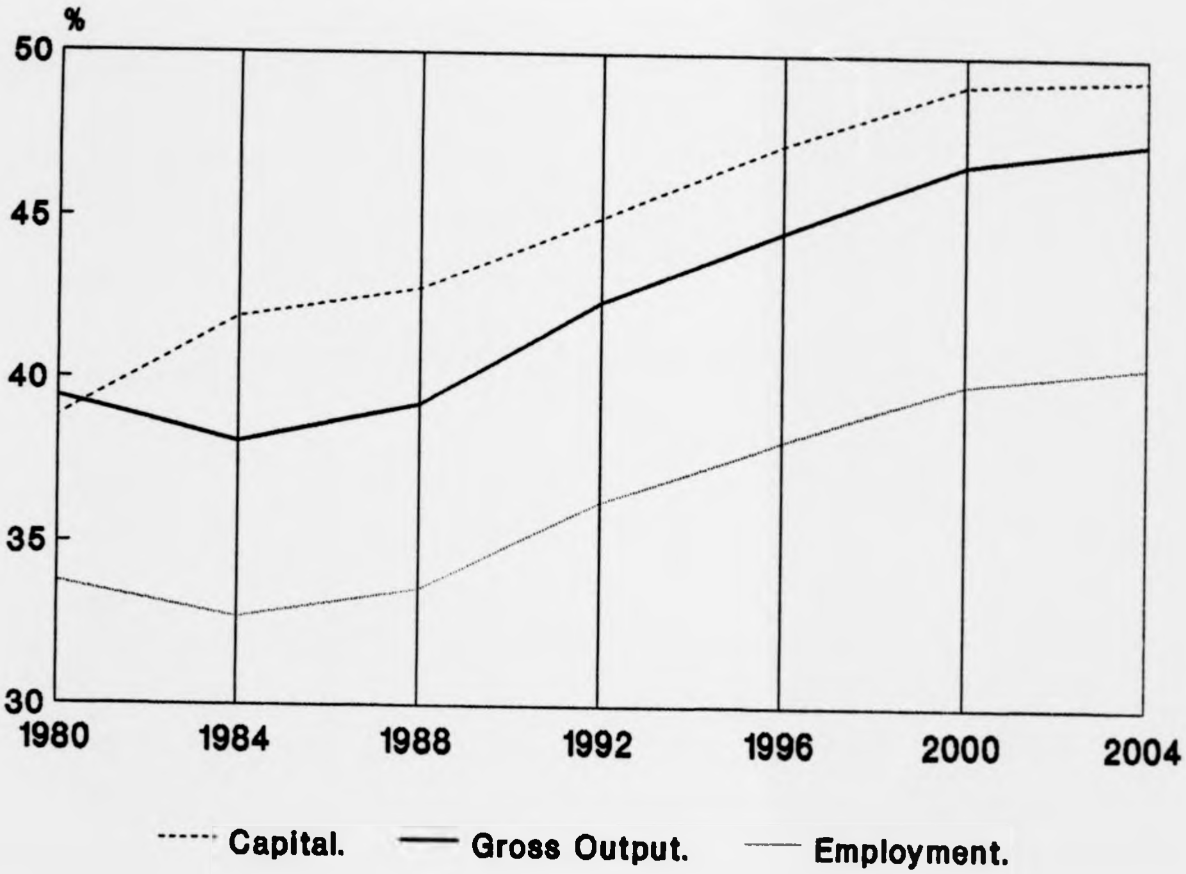


Figure 6.6 Share of Nontradeables in Dom. Economy.

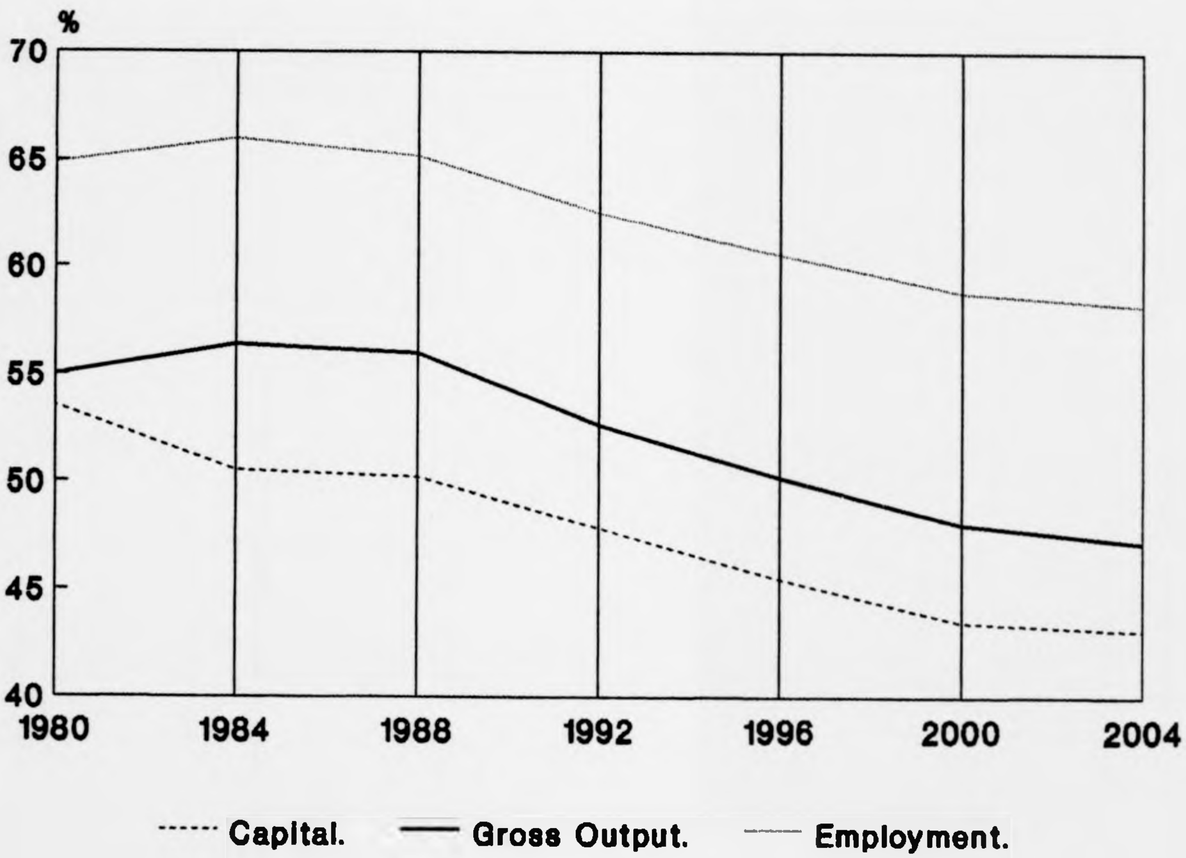


Table 6.5
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	654.9	684.6	692.1	717.7	733.4	746.9	1.6
Min	97.8	120.9	186.2	208.1	224.4	238.6	260.8	4.2
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	118.1	156.9	224.7	270.4	308.4	354.4	5.6
Pet	19.7	28.6	31.2	34.6	38.3	38.5	40.6	3.1
MCa	647.0	952.3	1421.4	2060.1	2295.1	2450.1	2620.2	6.0
MRe	1649.4	1994.5	2316.2	2624.1	3246.2	3975.6	4226.7	4.0
Con	608.3	691.9	613.5	625.6	643.9	651.0	721.2	0.7
Ele	78.9	169.4	213.6	237.0	258.7	270.2	279.3	5.4
Tra	404.8	578.6	707.8	792.3	903.7	953.0	1013.8	3.9
Com	1261.9	1929.7	2189.7	2490.0	2566.5	2655.9	2685.7	3.2
Ser	1249.6	1639.6	1904.0	2223.0	2312.0	2413.0	2424.9	2.8
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

[1] Average annual growth rate, 1980-2004.
* Exogenous.

Table 6.6
Sectorial Shares in Output, 1980-2004.

Sector	1980	1984	1988	1992	1996	2000	2004
Agricult.	6.9(6)	6.7	6.1	5.3	4.9	4.6	4.5(6)
Mining	1.3(10)	1.2	1.6	1.6	1.5	1.5	1.6(12)
Oil + Gas	4.0(9)	4.0	3.1	3.0	3.0	3.0	3.0(9)
Refining	1.3(11)	1.2	1.4	1.7	1.9	1.9	2.2(10)
Petrochem.	0.3(13)	0.3	0.3	0.3	0.3	0.2	0.2(13)
M Capital	8.8(4)	9.8	12.6	15.6	15.8	15.5	15.8(3)
M Rest	22.4(1)	20.4	20.5	19.9	22.4	25.1	25.5(1)
Construc.	8.3(5)	7.1	5.4	4.8	4.4	4.1	4.3(7)
Elect.	1.1(12)	1.7	1.9	1.8	1.8	1.7	1.7(11)
Transp.	5.5(8)	5.9	6.3	6.0	6.2	6.0	6.1(5)
Commerce	17.1(2)	19.8	19.4	18.9	17.7	16.8	16.2(2)
Services	17.0(3)	16.8	16.9	16.9	15.9	15.3	14.6(4)
Governm't	6.0(7)	5.1	4.6	4.3	4.2	4.2	4.3(8)
Traded	39.4	38.1	39.2	42.4	44.6	46.7	47.4
Nontraded	55.0	56.4	56.0	52.6	50.2	48.1	47.2
Oil	5.5	5.5	4.8	5.0	5.2	5.2	5.4

Note: Figures in parentheses denote sectorial ranking in terms of shares in total output.

The most obvious characteristic of the results of Table 6.6 is that with the exception of the proportion of output in agriculture which decreases over time, the other three traded sectors show significant increases in their sectorial shares as compared to the pre-plan period. In particular, the share of capital goods manufacturing sector in the total went from 8.8 percent in 1980 to 15.8 percent in 2004, which partially explains its impressive performance in terms of export revenues. On the other hand, it is important to single out from Table 6.5, the collapse in construction output during the 1984-88 period and its posterior slow recovery, which, as shall be seen later, coincides with the behaviour of investment by sector of origin. This is not, of course, a surprising result, because construction represents one of the most important sources of investment (see B matrix in the appendix).

Table 6.7 below summarizes the growth pattern for the three broad sector categories distinguished in the model.

Table 6.7
Weighted Annual Sectorial
Growth Rates, 1980-2004
(Percentages)

Period	Traded	Nontraded	Oil
1980-1984	6.5	8.2	8.5
1984-1988	5.3	2.9	0.5
1988-1992	5.2	3.1	5.0
1992-1996	4.0	1.3	3.4
1996-2000	3.5	1.1	2.4
2000-2004	1.6	0.7	2.3
1980-2004	4.4	2.9	3.7

Over the 1980-2004 period, domestic production of tradeables has to grow more rapidly than domestic production of both non-tradeables and oil related sectors. The deviation from balanced growth is most pronounced in the 1984-88 period during which the structural adjustment process is particularly dramatic.

The above transition of the Mexican economy, which characterizes the base run's optimal growth path, is determined by the structure of demands as well as by the opportunities for import substitution that exist.

Supply Side Changes:

On the supply side, non-competitive imports are specified as constant proportions of output. The non-competitive imports for capital formation are constant proportions of investment so their amounts and composition will vary with the investment levels and sectorial composition to be described below.

The major source of flexibility in supply is in the allocation of foreign exchange for competitive or discretionary imports. The possibility of using foreign exchange for competitive imports depends on the availability of such exchange, above the imposed requirements for non-competitive imports for intermediate demand and for investment. In fact, as seen before, in the reference case solution the economy has to reduce the share of both types of imports: domestic intermediate and final consumption. Yet, it is striking that all the competitive imports which are possible [14] are allocated only to the agricultural sector in each period in which

[14] Competitive imports are allowed in five sectors: agriculture, mining, refining, and the two manufacturing sectors.

there is foreign exchange over and above that required for non-competitive imports.

Table 6.8 indicates the amount of such imports and their proportions of gross output of the agricultural sector. This proportion which was zero in 1980-84, rose continuously afterwards, reaching 23.2 percent in 2004.

Table 6.8
Competitive Imports in Agriculture
(Level and Share of Gross Output)

Period	Value[1]	Share
1980	0.0	0.0
1984	0.0	0.0
1988	61.6	9.0
1992	95.3	13.8
1996	127.0	17.8
2000	150.7	20.5
2004	173.0	23.2

[1] In 1980 billions of pesos.

This result implies that agricultural imports are increasingly cheaper than domestic agricultural, whereas there is import substitution in terms of mining, refining and both manufacturing products throughout the planning period, as was implicit in Figure 6.4. On the other hand, this result also reflects the fact that although the foreign exchange constraint diminishes over time, there are still limited foreign exchange earnings, that affect the domestic economy in various ways. One way is through tightness in supplies of imported goods which, in turn, restricts domestic output.

Also, on the supply side, Figures 6.5 and 6.6 show that capital stocks in the tradeable sectors grow more rapidly than in the NT sectors, thus contributing to the expansion of the domestic tradeables in the economy.

Demand Side Changes:

On the demand side, there are the following sources of change:

(1) There are price-sensitive changes in consumption patterns by virtue of the ELES. Tables 6.9 and 6.10 present the consumption patterns for the nine goods and services and the six time periods, and the shares of each commodity in the total, respectively.

Table 6.9
Consumption Patterns, 1984-2004.
(1980 Billions of Pesos)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	242.7	251.5	276.9	288.3	271.4	263.7	0.4
Mining	0.2	0.2	0.2	0.2	0.3	0.3	2.0
Refining	46.5	52.3	60.8	73.1	91.3	117.8	4.8
M Capital	130.5	141.4	169.6	195.9	193.9	238.4	3.1
M Rest	958.3	1050.1	1206.1	1349.7	1298.6	1410.2	2.0
Elect.	42.8	50.0	60.1	70.1	74.7	81.5	3.3
Transp.	302.3	348.0	383.2	444.0	478.8	511.6	2.8
Commerce	933.0	1092.0	1261.5	1469.2	1798.5	1825.4	3.4
Services	747.1	853.6	998.8	1169.0	1262.1	1348.1	3.0

[1] Average annual growth rate, 1984-2004

Table 6.10
Consumption Shares, 1984-2004
(Percentages)

Sector	1984		1988	1992	1996	2000	2004	
Agricult.	7.1	(5)	6.6	6.3	5.7	5.0	4.6	(5)
Mining	0.0	(9)	0.0	0.0	0.0	0.0	0.0	(9)
Refining	1.4	(7)	1.4	1.4	1.4	1.7	2.0	(7)
M Capital	3.8	(6)	3.7	3.8	3.9	3.5	4.1	(6)
M Rest	28.2	(1)	27.4	27.3	26.7	23.7	24.3	(2)
Elect.	1.3	(8)	1.3	1.4	1.4	1.4	1.4	(8)
Transp.	8.9	(4)	9.1	8.7	8.8	8.8	8.8	(4)
Commerce	27.4	(2)	28.4	28.6	29.0	32.9	31.5	(1)
Services	21.9	(3)	22.1	22.5	23.1	23.0	23.3	(3)
Traded	39.1		37.7	37.4	36.3	32.3	33.0	
Nontraded	59.5		61.0	61.2	62.3	66.0	65.0	

Note: Figures in parentheses denote sectorial ranking in terms of shares in total consumption.

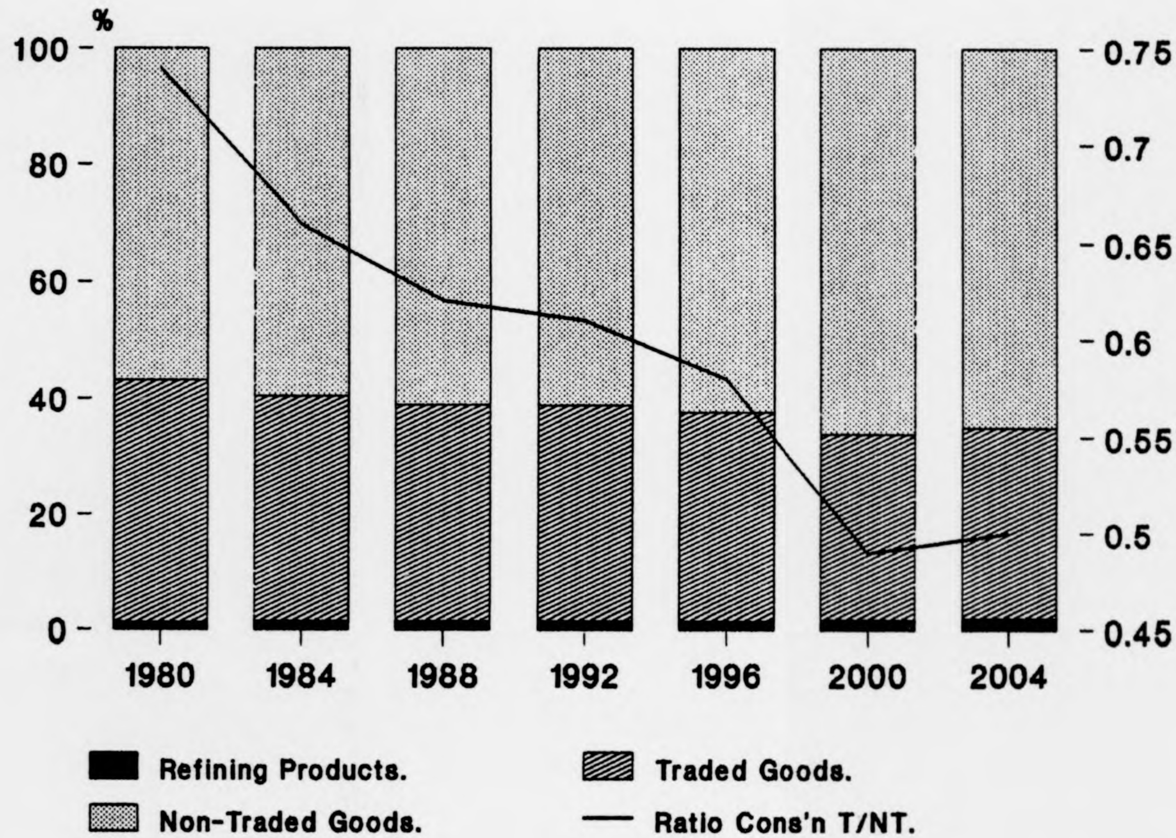
As Table 6.9 shows, there is a steady increase in the consumption levels for the nine goods throughout, although on average the domestic demand for non-tradeable goods grows faster than the consumption of tradeables. The changes in consumption patterns that occur in the course of economic growth can also be seen in Table 6.10 and Figure 6.7: there is substitution away from traded goods. The ratio of consumption of tradeables over NT goods falls significantly (24 points) during the 1980-2004 period, as required by the base run's optimal path.

(2) A second source of change on the demand side comes from the price-induced substitution possibilities between primary inputs through C-D production functions for all sectors [15]. That is, there is scope for changes in production input proportions. As was shown in Figures 6.5 and 6.6, Mexico adjusts to a new type of economy where growth comes mainly not from increases in nontradeables or oil and gas production, but from productivity growth and factor accumulation in the non-oil tradeable economy: these sectors increased their share of both capital and labour input proportions by about 10 points along the model's horizon.

On the other hand, and as expected, there is full employment of the three labour categories because of the

[15] On the other hand, it is important to recognize that there is no technological change which adjusts intermediate inputs and non-competitive imports proportions.

Figure 6.7 Optimal Consumption Patterns.



C-D's unitary elasticity of substitution (see the results of equation LMKT shown in Appendix B) [16].

(3) The third and perhaps most dramatic change in demand is illustrated by the flexibility that exists in the model in terms of the endogenous determination of the exports of the oil and gas sector (up to the limit imposed by the authorities on production levels), as well as by the two manufacturing exports [17]. The net effect of the abrupt decline in external loans and the limitations faced by oil revenues is a rapid increase in manufacturing exports. This transition is captured by Figure 6.8 which separates exports into its three components: oil and gas, manufacturing and other tradeables.

(4) The final source of change in the demand side involves investment by sector of destination, where its composition and levels can and do change from period to period, as Figure 6.9 shows for the case of the three broad sectors. Revenues from oil and gas imply decumulation of wealth unless they are converted into other productive assets. Moreover, given that oil exports are displaced by manufacturing exports as the main source of foreign earnings, there is the need for a change in the optimal allocation of investment. As Figure 6.9 depicts, an increasingly high proportion of investment

[16] Section 6.4 discusses the efficiency price differentials between labour categories.

[17] The remaining structure of exports was projected exogenously, so there was no flexibility in demand there. Similarly, the levels and composition of government demand are also determined exogenously to the model.

Figure 6.8

The Composition of Exports.

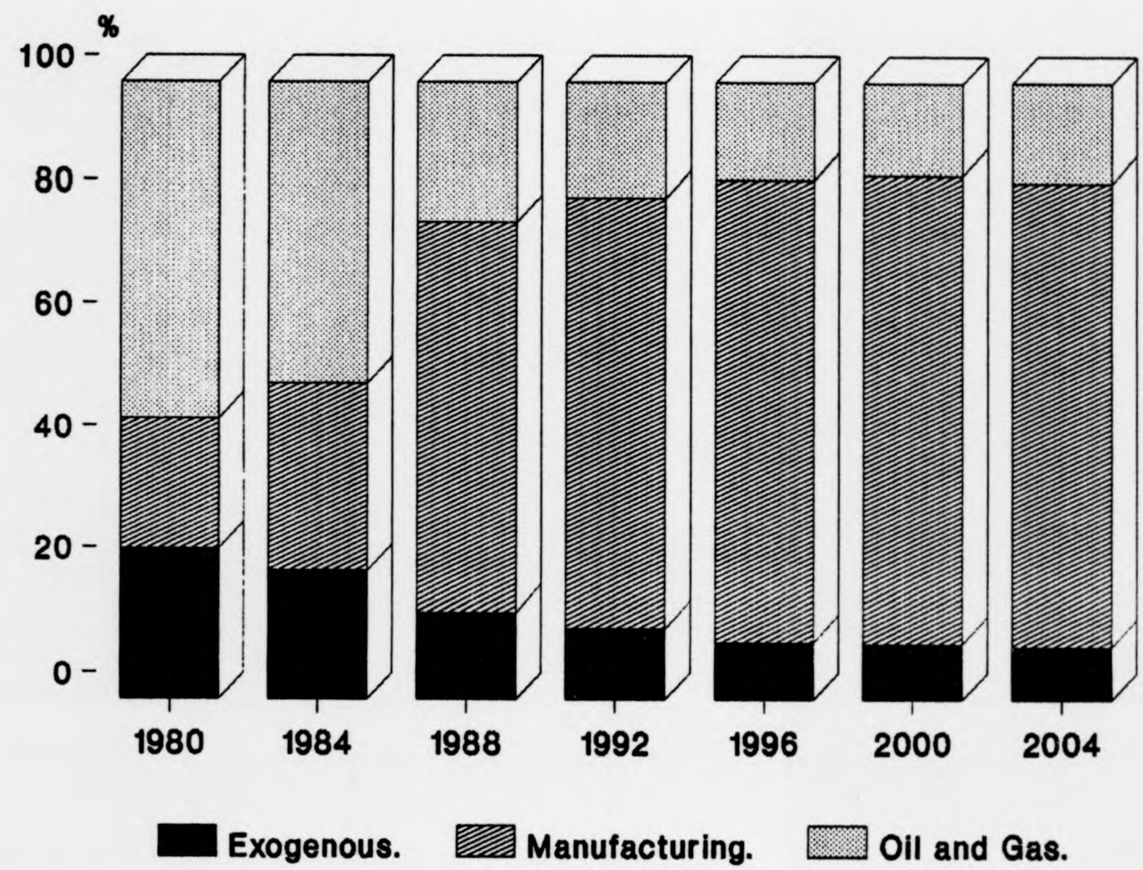
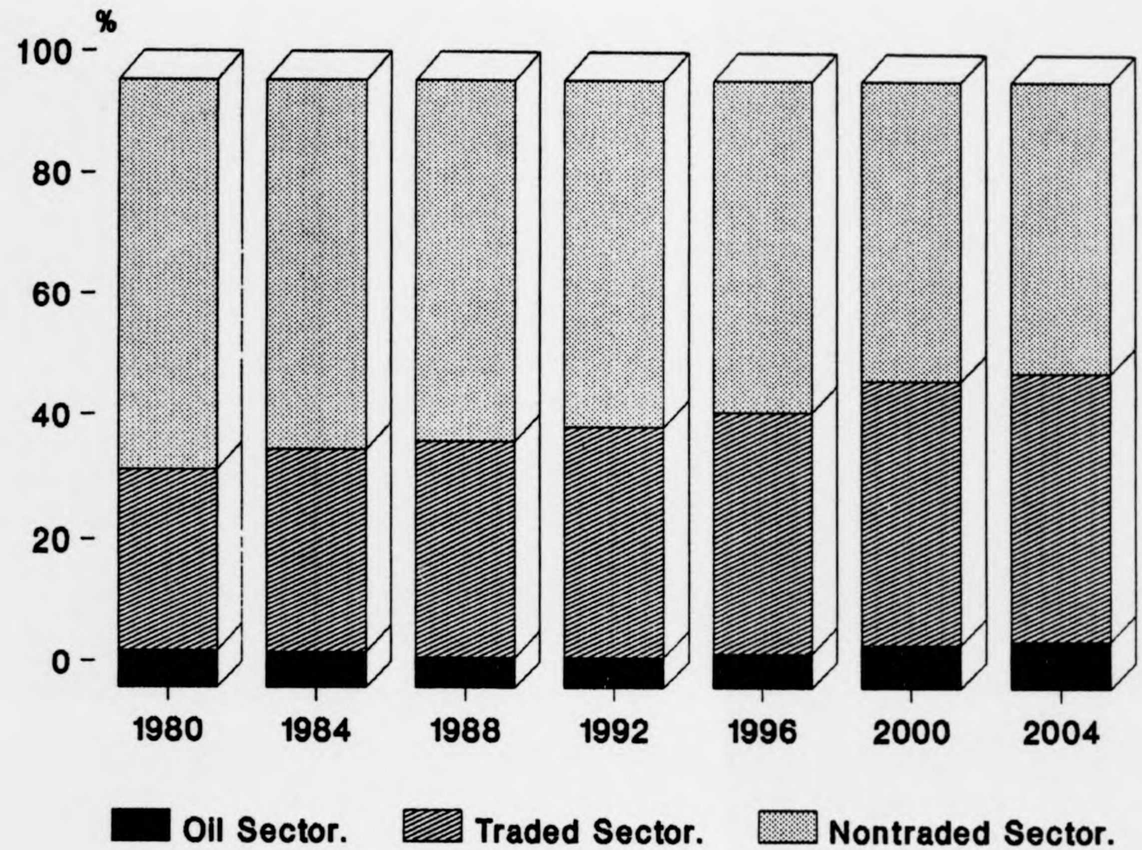


Figure 6.9

Optimal Allocation of Investment.



expenditures should be directed into the tradeable sector, specifically into both types of manufacturing industries [18]. That is, the emphasis in terms of the allocation of real capital assets should be not on housing, schools, and social infrastructure but rather, export and import competing commodity producing sectors reserve top priority [19].

In sum, the above results show that the pattern of sectorial output growth is affected by the composition of demands: intermediate, consumption, investment, government, and exports, as well as by the relative costs of domestic production as compared to the cost of imports. All these sources of change work in the same direction, for the base run of the model, towards a structural adjustment process: expansion of non-oil export and import-substituting activities.

National Economic Resources:

As argued in previous chapters, Mexico's total wealth can be decomposed into: (i) real capital assets (factories, infrastructure, etc [20]); (ii) oil and gas reserves; and (iii) financial claims on the rest of the world (reserves in the Bank of Mexico, etc). The process of saving and

[18] Both manufacturing industries increase their share on total investment expenditures by the tradeable sector: from 70 percent in 1980 to almost 90 percent at the end of the planning period.

[19] It is also important to note that investment in NT sectors such as schools is relatively low partly because of the way in which the model is formulated. For example, the supply of skilled labour is determined exogenously, so that programmes such as education or other sources of productivity change are ignored in the model.

[20] In this context, human resources can be thought of as real capital assets. They can be increased by real investment in a manner similar to physical capital formation.

investment can add or subtract in relation to these types of wealth and the optimal decision basically depends on the returns that society can obtain on additional investment, on the consumption requirements that must be satisfied, on society's long-term willingness to save, and on the terms on which domestic resources can be complemented by foreign capital. There are also physical and technological constraints, in particular, the size and composition of the productivity labour force, and the exhaustible resources constraints.

Within this framework, the model decides, as seen previously, to "decumulate" the second type of wealth by depleting hydrocarbon reserves, and to "accumulate" the third type of assets by making external debt repayments. These debt repayments and the consequent large net outward resource transfers from Mexico to abroad came to a large extent at the expense of investment in real capital assets. In effect, investment collapsed from 1394.1 billions of pesos in 1984 to 1180.2 billions of pesos in 1988, an average fall of 4.1 percent in real terms per year in that period. Thereafter, as the foreign exchange constraint diminishes, investment increases gradually from 1988 onwards as Table 6.11 describes.

Table 6.11
Investment Patterns, 1984-2004.
(1980 Billions of Pesos)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	27.8	33.2	38.2	39.2	53.1	54.0	3.4
Mining	0.6	0.4	0.4	0.4	0.5	0.7	0.8
Oil	0.5	0.5	0.5	0.6	0.6	0.7	1.7
Refining	0.3	0.4	0.5	0.6	0.6	0.7	4.3
Petrochem	0.1	0.1	0.1	0.1	0.1	0.1	0.0
M Capital	403.9	349.2	347.5	474.8	385.6	503.0	1.1
M Rest	68.0	35.3	38.2	48.5	59.1	71.6	0.3
Construc.	691.9	613.5	625.6	643.9	651.0	721.2	0.3
Elect.	2.6	2.0	2.3	3.1	3.9	4.4	2.7
Transp.	0.5	0.3	0.4	0.5	0.6	0.7	1.7
Commerce	166.4	119.1	122.8	147.7	226.9	236.0	1.7
Services	31.5	26.2	27.3	30.4	40.0	41.2	1.4
Total	1394.1	1180.2	1203.8	1389.8	1422.0	1634.1	0.8

[1] Average annual growth rate, 1984-2004.

Table 6.11 also shows that the sharp fall in investment during 1984-88 was stronger in the traditional investment goods sectors: construction and manufacturing of capital goods. This lack of investment by sector of origin is translated into shortages in investment by sector of destination and, ultimately, in capital stocks and other bottlenecks in infrastructure, which severely restrict the growth of the economy as a whole, and in particular the growth of non-tradeable sectors as shown by Figure 6.6.

Thus, it is almost certain that for the base case, the return on investment is lower than the real rate of interest on foreign debt (8 percent), which further encourages debt repayments (i.e. there is a portfolio switching effect towards retirement of foreign debt since it is the most profitable (i.e. has the highest rate of return) asset of the three that constitute Mexico's wealth). Also, the model decides that Mexico's national income be allocated mainly to consumption, which rises at a slightly higher rate than GDP (see Table 6.2). Consequently, domestic savings are insufficient to maintain the levels of investment of the earlier periods, which in turn, do not generate the capital stock necessary to achieve minimum rates of economic growth [21].

The magnitude of the net transfer of resources determines, therefore, together with the exogenous terminal-year capital stock prices and the discount rate applied to consumption, the combination between consumption and investment at the present time and in the future. Table 6.12 presents both observed and estimated figures for net transfer of resources, consumption and investment. As this Table shows, during the last six years, the Mexican economy suffered a dramatic decline in investment, much more acute than consumption's fall. It also describes the intertemporal decline of investment expenditures as percentage of GDP during the model's base run horizon: from 29.5 percent in the early 1980's to only 21.3 percent on average over the 1980-2004 period, whereas consumption increases slightly in per capita terms.

[21] The minimum growth for the economy can be defined, for instance, in terms of the growth required to absorb the country's expanding labour force.

Table 6.12
Total Net Transfer of Resources,
GDP, Consumption and Investment.

Period	TNTR[1] (% GDP)	GDP (Δ %)	Consumption (% GDP)	P.C.[2]	Investment (% GDP)
1960-1970*	4.3	7.0	78.5	30.3	19.2
1971-1976*	3.6	6.2	76.9	39.4	21.6
1977-1982*	2.3	6.2	75.0	46.4	23.0
1983-1988*	-5.5	-0.4	73.7	44.7	16.8
1980-1984	22.3	1.4	72.0	44.6	29.5
1984-1988	-8.1	2.4	74.0	46.4	22.7
1988-1992	-5.4	4.0	72.8	45.8	19.8
1992-1996	-4.1	4.7	69.3	48.6	19.0
1996-2000	-3.3	2.3	68.5	49.0	17.8
2000-2004	-3.0	1.7	67.9	48.6	19.1
1980-2004	-4.8 3	2.7	70.8	47.2	21.3

* Observed figures. Source: SHCP (1988).
1 Observed figures for net transfer of resources include: total gross debt + direct foreign investment + other incomes from abroad - gross principal payments - interest payments - other payments. TNTR calculated by the model include total debt in net terms and interest payments. Minus sign indicates outflow of resources abroad.
2 P.C.=Per Capita. 1980 billions of pesos.
3 1984-2004.

Besides characterizing the optimal growth paths in terms of the level and allocation of investment, the rate of oil and gas extraction, the composition of exports, and the mix of domestic savings and foreign borrowing, the model generates paths for the dual variables or shadow prices associated with each constraint. These shadow prices provide the crucial link between long-run optimal growth considerations and more partial sector studies and project evaluation. In the following section, the structural adjustment process characterizing the optimal growth path shall be discussed again, but now from the price side of the model. One of the questions that shall be assessed is: how should the real exchange rate behave to support the optimal growth path seen in the real side of the model?

6.4 Dual Results.

In an optimizing GE model, the shadow prices represent the relative prices which would lead an efficient market towards the optimal outcome on the real side. By definition, the shadow price associated with each constraint in the model is the amount by which the objective function would increase if the constraint was relaxed by one unit. However, despite this simple definition, the shadow prices which are printed with each solution are often difficult to interpret. There are several general characteristics of shadow prices which must be recognized in order to understand their meaning [22].

First, the price structure of models reflects the built-in economic efficiency. Marginal costs are equated with marginal benefits for activity undertaken, such as consumption, investment, or domestic production. If the costs of an activity exceed benefits, when both are measured at shadow prices, the level of that activity is set at zero. Similarly, the shadow price associated with a particular constraint is positive only if the constraint is binding in the optimal solution.

---

[22] The following discussion is based on Goreux and Manne (1973), Taylor et al. (1975), and Dervis et al. (1982).

Second, in absolute terms, the shadow prices generally decrease over time. This does not mean that the model is projecting a fall in market prices, but rather, it reflects the way in which the model does its internal discounting. That is, in present value terms, it is preferable to have an extra unit of say, consumption, sooner rather than later [23].

Third, examining the shadow prices of the different goods within any one period, it is clear that the relative prices are far different from their actual values in 1980 when all relative prices were set to unity by appropriate choice of units. The fact then, that relative prices change, reflects the model's ability to make economic decisions based on real factor scarcities.

Finally, the model numbers which the computer generates are arbitrary in the sense that the optimal solution would not change if the coefficient of the maximand was re-scaled by one constant factor. This, together with other considerations, implies that the shadow prices of the model only make sense in relative terms, which measure the contribution of one factor against another.

In presenting the shadow prices, a choice has been made to denominate them in terms of their value relative to the cost of foreign exchange. The reason is the scarcity of foreign exchange that Mexico faces nowadays

---

[23] There are sometimes, of course, exceptions, where for example, the costs of production are increasing at a very rapid rate.

[24]. Hence, for each period the actual shadow price, taken from the computer printout, for each good, is divided by the shadow price of foreign exchange in that period. The results of these transformations are shown in Table 6.13:

Table 6.13
Shadow Prices of the Base Run
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.06	1.14	1.25	1.26	1.30	0.5
Mining	0.50	0.38	0.41	0.41	0.42	0.47	-0.3
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.62	0.46	0.49	0.50	0.54	0.54	-0.7
Petrochem	0.59	0.44	0.47	0.47	0.50	0.51	-0.7
M Capital	0.96	0.83	0.83	0.84	0.86	0.93	-0.2
M Rest	1.02	0.88	0.91	0.93	0.98	1.01	0.0
Construc.	0.91	0.72	0.56	0.60	0.63	0.66	-1.6
Elect.	1.14	0.92	0.91	0.89	0.85	0.82	-1.6
Transp.	0.67	0.55	0.59	0.58	0.56	0.51	-1.4
Commerce	0.82	0.78	0.68	0.64	0.59	0.54	-2.1
Services	0.86	0.79	0.76	0.70	0.63	0.62	-1.6
Governm't	0.77	0.67	0.67	0.65	0.65	0.56	-1.6
Agg. Cons.	0.919	0.822	0.812	0.805	0.796	0.790	-0.8
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.771	0.432	0.242	0.132	0.085	
Δ% FERP	-6.3	-13.5	-13.5	-14.1	-10.4		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
Δ% FERP = Rate of change in FERP.

In this Table, the shadow prices for each sector in each period are simply the nominal values for that sector (the marginal values for the material balance constraint appearing in the solution report of GAMS) divided by the nominal shadow price of foreign exchange for that period (the marginal values for the foreign exchange

[24] Another choice could have been, for example, to denominate the shadow prices in terms of their value relative to the cost of a unit of private consumption.

constraint). The last two rows of Table 6.13 include the actual time-path of the foreign exchange shadow price, relative to its value in period 1 (1984), and the annual rate of discounting of foreign exchange between each period.

It is interesting to see, on the other hand, that the shadow prices for the majority of the goods are relatively stable throughout, particularly, during the last period. This seems to indicate that the way in which the terminal conditions problem is handled in the model is plausible.

In order to assess whether a particular good is becoming more or less expensive over the time period, relative to foreign exchange, it is necessary to examine whether the numbers in that particular row are rising or falling. For instance, the shadow prices for crude oil reflect the exogenously specified growth in their real price. It became less expensive during the 1984-88 period because of the fall in its price, whereas from 1988 onwards, the opposite is the case, given that an annual oil price increase of 2 percent in real terms was stipulated. It also stands out from this analysis that with the exception of construction all non-traded goods and services become less expensive in terms of foreign exchange throughout, whereas the opposite occurs with both traded goods and oil related products. As shall be explained later on, this is just the price counterpart of the structural adjustment process described for the real side of the model.

The relative price structure in each period can be seen by examining the shadow price column for that period. If a price is less than unity, one unit of that good, defined as 1 billion pesos worth at 1980 prices, is worth less than one unit of foreign exchange and viceversa. As can be seen in Table 6.13, the shadow prices of agricultural products, the two manufacturing goods, and of electricity are relatively high, whereas the shadow prices of the remaining goods and services are, for most periods, relatively low. This result shows that one unit of foreign exchange is worth more than one unit of almost any other good, including oil related products.

The relatively low shadow price of the oil and gas extraction sector is because oil has a lower expected rate of price increase. In other words, the majority of export earnings are no longer supplied by this sector, but rather are now due to the two manufacturing industries. Accordingly, the shadow price of the two manufacturing goods is relatively high. Regarding the relatively high shadow price of agricultural products, it can be explained by the fact that imported agricultural goods are increasingly cheaper than their domestic counterpart (i.e. the demand for agricultural commodities is foreign exchange intensive). By contrast, the shadow prices for non-traded goods, such as: construction, commerce, services and government, are low in relative terms because they are not intensive users of imported raw materials.

The relatively high shadow price of electricity is more striking given that it is also a non-traded good produced with natural gas and petroleum products. Yet, it is also a necessary input into all types of production, including manufacturing goods, as well as being used for personal consumption.

In sum, the shadow prices shown in Table 6.13 can be interpreted as a signal that the whole system can be more productive when the foreign exchange constraint is loosened.

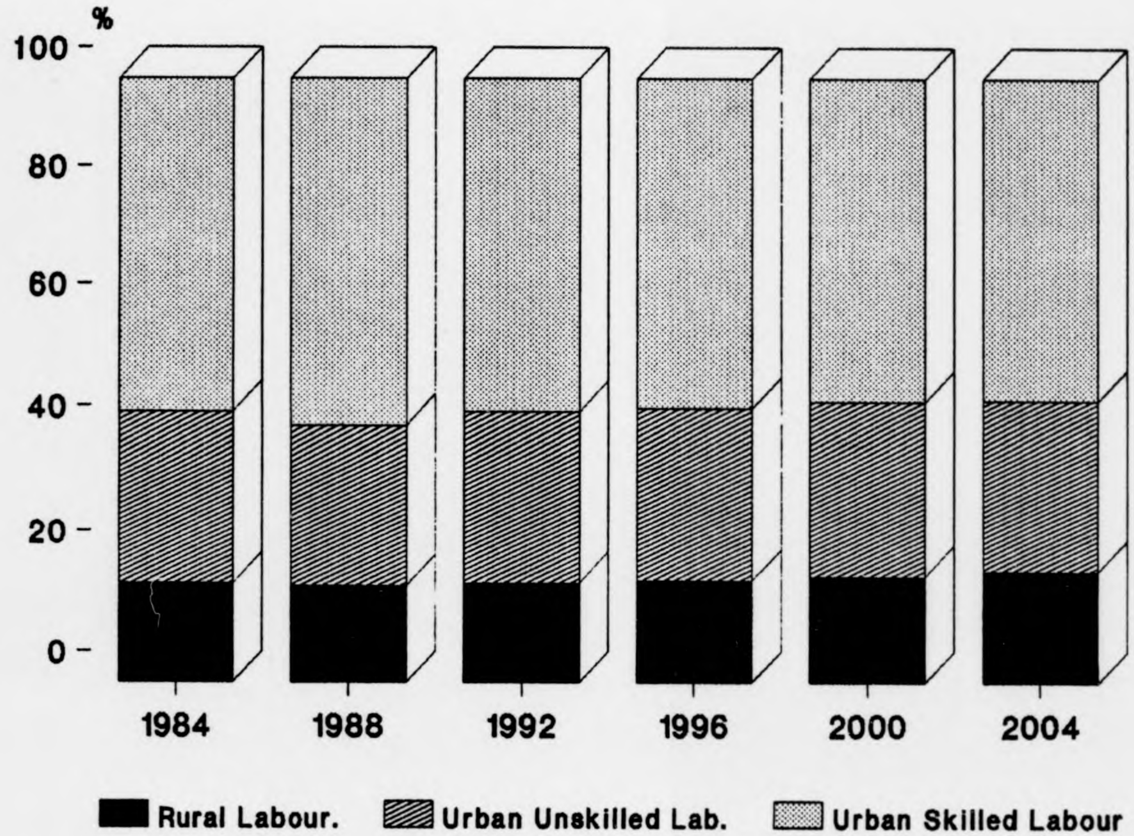
Efficiency Wage Differentials:

As already mentioned, in this base run of the model there is full employment of the three labour categories. This result is reflected in the dual solution through the labour market constraint (see the relevant equation in section 5.2), which is binding (i.e. the shadow prices are positive) for each skill group and every time period.

Figure 6.10 presents the efficiency price differentials between skill groups for the 1984-2004 period. The intertemporal pattern of shadow prices for the three labour categories simply reflects the demand that exists for each labour group in relation to their respective exogenously projected supplies. The labour group in most demand is urban skilled, followed by urban unskilled and

Figure 6.10

The Composition of Wages.



then by rural labour [25]. Hardly surprising then, the shadow price of urban skilled labour is higher than the least skilled labour categories: on average, rural wage represents 17 percent of total wages or about one-third of urban skilled wage which, in turn, takes more than 50 percent of the total. Urban unskilled wage, on the other hand, amounts to half the urban skilled wage. Similarly, rural wage represents about 60 percent of urban unskilled wage.

Given that in this base run of the model, full employment of the three labour groups is 'forced' because of the C-D's unitary elasticity of substitution, it has not been possible to analyze the extent to which the Mexican economy is restricted by labour skill shortages. In future scenarios, however, the degree of substitution between labour categories shall be modified in order to allow for the possibility of skilled labour restrictions, and so evaluate its impact on oil and gas extraction levels, investment decisions, economic growth, as well as on the ability of the economy to absorb export revenues (see section 7.1).

Real Exchange Rate:

Section 3.2 discussed how changes in the level of "Exogenous" Resources (i.e. net foreign capital inflows

---

[25] In 1980, for example, it is estimated that the share of urban skilled and urban unskilled in total labour's value added across sectors amounted for about 60 and 25 percent respectively, while the remaining fraction corresponded to rural labour.

plus oil revenues [26]), were expected to affect relative prices in a simple traded-nontraded model: increasing Exogenous Resources results in appreciating real exchange rate, that is, an increase in the relative price of non-traded goods. By contrast, a real depreciation should be associated with declining inflows, to facilitate substitution, away from traded goods in consumption and toward them in production. As was noted in that theoretical model, the magnitude of the adjustment required depends on "how different" domestic tradeables are from domestic non-tradeables, in the way they combine factors of production. If production characteristics were identical between the two sectors, the output of tradeables could expand without the need for a rise in their relative price. This, of course, assumes perfect mobility, the present model in fact postulates that capital goods are mobile ex ante but not ex post (sector-specific capital technology). On top of that, the description of the Mexican economy is considerably more complicated than the simple two goods model, making the dynamic behaviour and indeed the definition of "the" real exchange rate also more complex.

[26] It should be borne in mind that while there are some significant differences between oil revenues and foreign aid flows, both represent a transfer the magnitude of which bears very little relationship to productivity, wages and resource growth in the non-oil domestic economy. That is why Dervis et al., 1984, call them "exogenous". It is also true that their magnitude is very much dependent on factors beyond the policy makers control such as world oil prices, etc.

To begin with there are many real exchange rate measures [27]. As Dervis et al. (1984) outline, when analyzing relative price adjustments required by a long-run structural adjustment process, it is important to distinguish between the relative price of domestic tradeables vis-a-vis non-tradeables, and the relative price of domestic goods in general (tradeables and non-tradeables) vis-a-vis goods produced by the rest of the world. The former relative price, which Dervis et al. call the internal real exchange rate, will have to change to bring about the required expansion in production of tradeable goods only to the extent that this sector uses a mix of factors of production very different from that used to produce non-traded goods.

On the other hand, the external real exchange rate should be distinguished from the internal relative price issue. Dervis et al. argue that even if there were no change at all in the non-tradeables/tradeables relative price, there would still be a need for a depreciation in the external terms of trade, or a decline in the relative price of domestic goods in terms of foreign goods, because exports cannot expand without an accompanying increase in external competitiveness. While the first kind of real exchange rate adjustment depends on the "degree of difference" between domestic tradeables and non-tradeables, the extent to which an external terms of trade adjustment is needed depends on the extent to which

[27] For a discussion about alternative measures of the real exchange rate and its importance for the analysis of trade and current account movements see, for example, Dornbusch (1987) and Helmers (1987).

a country must accept lower net export prices (net of transportation costs) when it wants to expand its world market share.

The results of the model's optimal solution can be used to calculate these types of changes since they are based on relative scarcities of the different factors which constrain the optimal solution. Figure 6.11 shows that the path of oil revenues plus foreign debt allowed some room at the beginning of the planning period (1980-84) to expand the ratio of those "external" resources to GDP. Thereafter, however, this ratio falls making non-oil tradeable goods scarcer and therefore, more expensive to consumers and more valuable to producers.

The behaviour of both real exchange rates reflect those changes as depicted in Figure 6.12: the price of non-traded goods in terms of tradeables and the price of all domestic goods relative to imports fall steadily from 1984 onwards. As already stated, those changes are required to give the incentives in production and consumption to adapt to a situation where foreign exchange revenues are provided mainly by non-oil exports, instead of foreign borrowing and oil related exports.

As was seen in Table 6.13, most non-traded goods and services become less expensive over time while the opposite occurs with traded goods. This result simply reflects the fact that a real depreciation of the internal exchange rate (the relevant definition for domestic resource allocation and the price counterpart of

Figure 6.11

Ratio of Exogenous Resources to GDP.

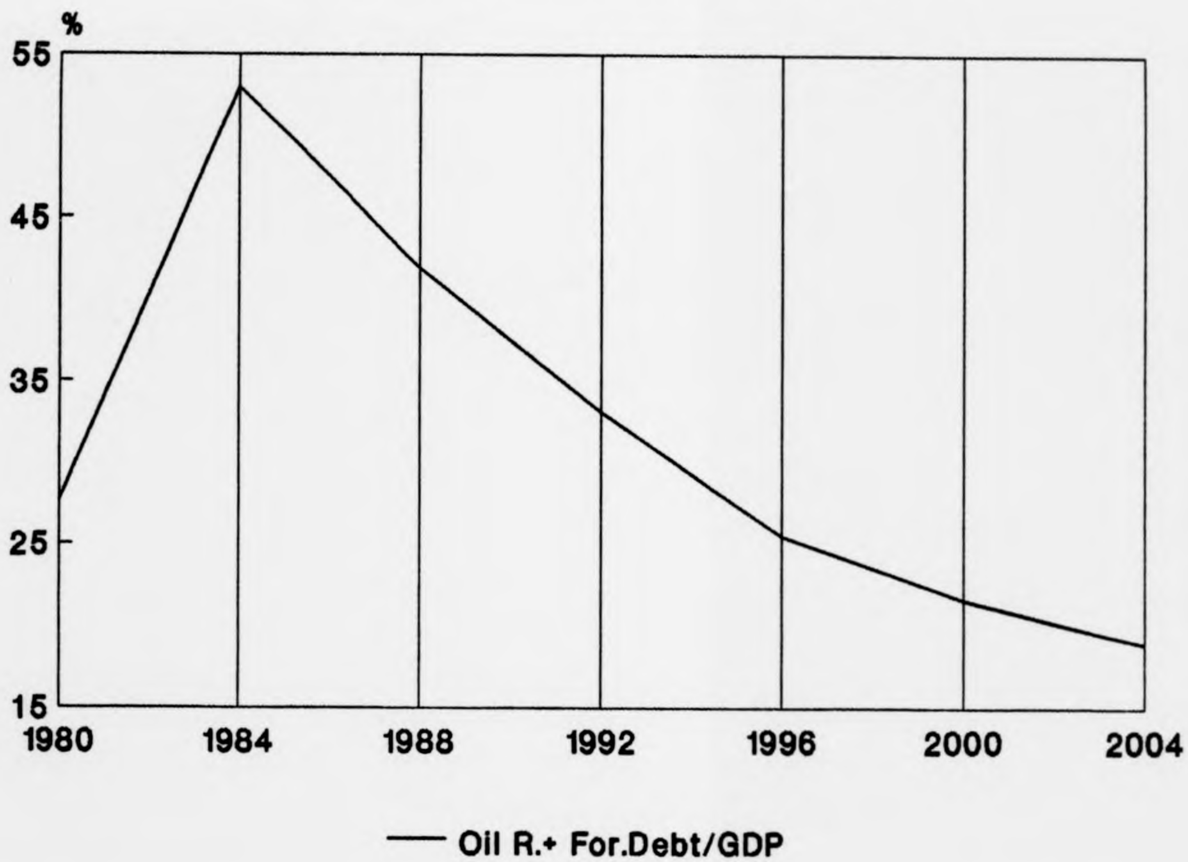
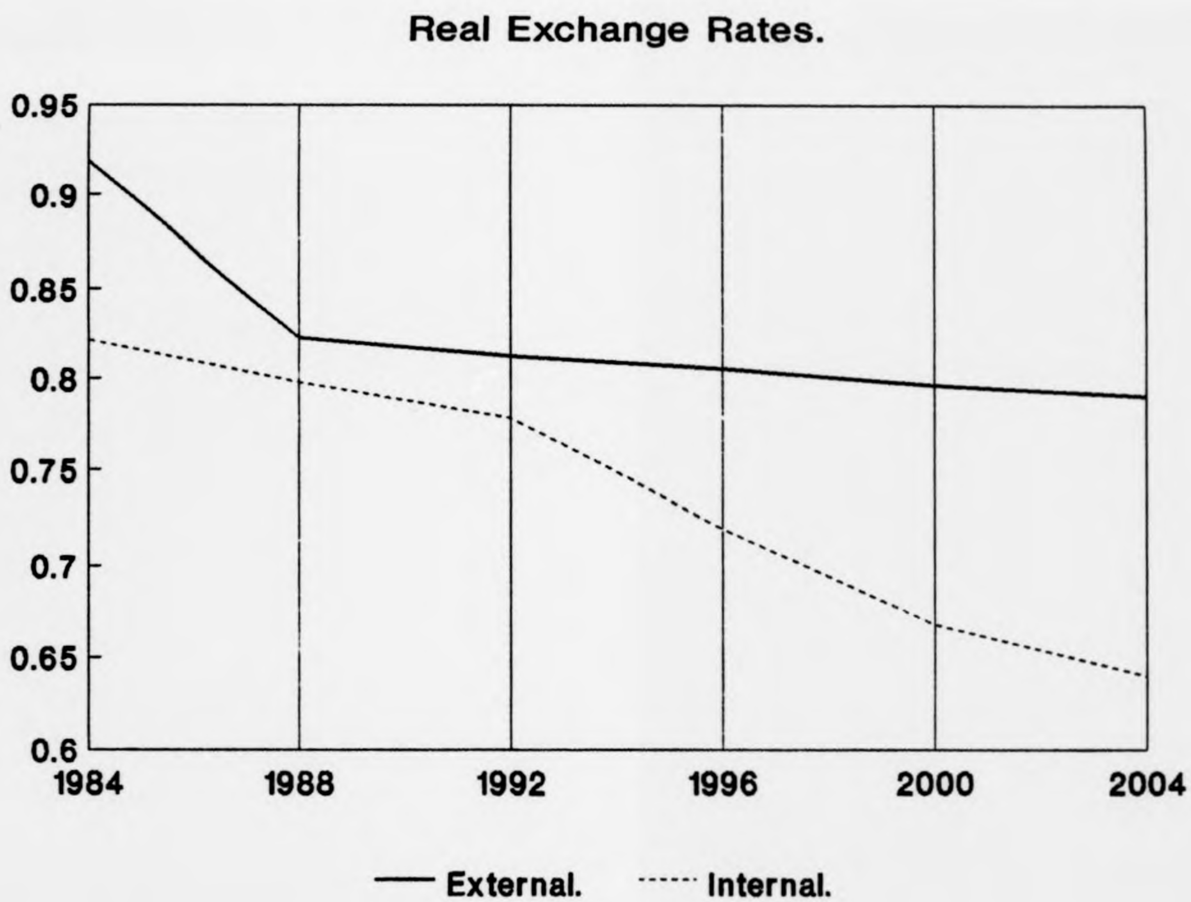


Figure 6.12



External = Dom.Goods/Imports.
Internal = Nontraded/Traded.

the increasing share of traded goods in both capital and labour seen in Figure 6.5), is called for to sustain this reallocation [28].

Figure 6.12 shows that the change in domestic relative prices is more severe in the 1992-2000 period when there is a real depreciation of about 2 percent per year. As mentioned earlier, this relative price reflects the degree of difference between traded and non-traded goods in the domestic market. Stylized facts about the Mexican economy suggest that the NT sector is less capital intensive (mainly because of the inclusion of public and private services) than the sector producing tradeable goods. Over the planning period there is a sustained decrease in the overall capital/labour ratio of the economy. The Rybczynski effect, therefore, tends to reduce, for a given composition of output, the price of the sector which is relatively more labour intensive, which further supports the reallocation of resources required to revert the dependence on Exogenous Resources [29].

Turning now to the external relative price issue, this is defined as the cost of a bundle of domestic goods (both traded and NT) relative to a bundle of imported

[28] The internal exchange rate is computed as a weighted average of the cost of domestic traded and non-traded goods in shadow prices, the weights being the gross output shares in both broad sectors.
[29] It is important to note, on the other hand, that since a rise in world oil prices is assumed in this base case, and given that NT sector is more energy intensive than tradeables (because NT includes such energy users as transportation and electricity), an increase in the price of energy tends to counteract the tendency towards a decline in the relative price of NT.

goods. For this purpose, a unit of private aggregate consumption can be taken as the appropriate bundle of domestic goods [30]. Hence, the aggregate consumption cost row of the shadow price table measures the cost in each period of a unit of consumption, in shadow prices, relative to the shadow price of foreign exchange, where the bundle is a unit of 1980 non-competitive imports. This value can be interpreted as the external real exchange rate for that period, and its inverse represents the world price relative to the consumer price index. In other words, even though the model does not predict either domestic or international inflation, it does give some clues as to the ratio between the two: if domestic prices increase faster than international prices, real appreciation of the external exchange rate is implied.

As was seen in both Table 6.13 and Figure 6.12, on aggregate domestic goods and services become less expensive relative to foreign exchange so that the peso depreciates or consumption costs fall over time relative to imported costs. This real depreciation is more pronounced during the 1984-88 period (10.6 percent equivalent to 2.8 percent per year), which is when the economy faced its most serious foreign exchange constraint (i.e. the system stopped receiving new external loans, started making principal payments, and

[30] This price is computed as a weighted average of the cost of the endogenous consumption bundle in a certain year, the weights reflecting expenditure shares at shadow prices. The external real exchange rate corresponds to the row called Aggregate Consumption of Table 6.13.

there was a reduction in oil export revenues) [31]. Thereafter, as the foreign exchange constraint diminishes [32], the rate of change in the external real depreciation also falls. The total real devaluation (1984-2004) is about 14 percent. An improvement in Mexico's external competitiveness, therefore, is necessary over that period because as seen before, manufacturing exports in particular and total exports in general should grow considerably faster than GDP over the planning horizon [33].

Thus, as the economy adjusts to lower exogenous inflows by producing more non-oil exports, the price of imports (the foreign good) rises relative to the prices of both domestic goods. This terms of trade effect forces a "devaluation" not in the sense of a rise in the price of domestically produced tradeables relative to NT, but in the sense of a rise on the price of foreign goods compared to domestic goods.

To conclude the real exchange rates issue, Mexico's transition from an economy where natural and foreign based resources account for more than half of GDP during early 1980's to an economy where the role of these

[31] The 1984-88 devaluation is, on the other hand, responsible, to a great extent, for the dramatic structural adjustment process described in the previous section: tradeables grow much more rapidly than the other two broad sectors in that period.
[32] The reduction in the foreign exchange constraint after 1984 is reflected, for example, in the increasing availability of foreign exchange that is used for competitive imports, as described in table 6.8.
[33] Recall from Table 6.1 that in this base run scenario, it is assumed a deterioration in Mexico's terms of trade which explains in part the behaviour of the external exchange rate.

resources is much more modest (i.e growth is based on the expansion of domestic tradeables, and foreign exchange comes primarily from industrial exports), requires a real depreciation of both the internal and external exchange rates.

Perhaps the most difficult aspect of interpreting the shadow prices is transforming them into projections of actual future prices which are consistent with each outcome. In addition to the relative prices shown in Table 6.13, global inflation and peso devaluation, roughly the difference between domestic and international inflation, must be considered. As Blitzer and Eckaus (1983, p.82) explain, a two step procedure is required to calculate the appropriate nominal domestic prices for each good. The first step is determining how many current pesos are needed to purchase the same bundle of imports that peso could purchase in 1980, because that is the unit of measure which is used. Then, the domestic price of any good is derived by multiplying the shadow price for that good, relative to foreign exchange, by the value for foreign exchange calculated in the first step.

For example, let us suppose that the actual market price of foreign exchange in 1984 would have been 8 to 1, implying that one 1984 peso could buy about one-eight the real quantity of imports that one peso could in 1980 [34]. The shadow price of the amount of crude oil which cost one billion pesos in 1980, approximately 1.5 million

[34] During the 1980-84 period, the preferential exchange rate (pesos per dollar at the end of the period), increased by a factor of 8.26.

barrels [35], for 1984 would be 8.26 * 0.92 (from row 3, column 1 of Table 6.13), which is equal to 7.6 billion pesos or about 5,066 pesos per barrel. This figure is equivalent to $26 at the official exchange rate, and is consistent with the observed price.

The same sort of calculation could be done to determine the actual shadow prices in later periods and for other goods such as kilowatt hours, refined and petrochemical products, etc. These can then be used either to provide insight into the setting of domestic energy prices under different policy assumptions, or as part of the government's evaluation of new investment projects.

The above represent the main results obtained with the base run of the model. This case was chosen as being of great interest in itself, and as the reference case against which alternative policy experiments can be compared. These results have thrown some light about some of the questions raised in chapter II, especially with respect to the interactions between energy-foreign debt and energy-industrialization. However, it is still too early to draw any conclusions as many alternative cases and sensitivity tests have to be implemented. This is the purpose of the following chapter.

[35] In 1980 the average price of Mexican oil was about $28.6 per barrel or 665.71 pesos per barrel at the official exchange rate. Hence, 1 billion pesos could buy about 1.5 million barrels of oil.

CHAPTER VII.

ALTERNATIVE SCENARIOS AND SENSITIVITY ANALYSIS EXPERIMENTS.

How much faith can be placed in the Base Run results reported in the previous chapter? In answering this question one has to emphasize, firstly, that the model has been designed as a laboratory for policy experiments, not as a forecasting model. In addition, the Base Run represents only one of many alternative scenarios that can be specified, each one reflecting various domestic policies and international trade and financial conditions. The purpose of this chapter, therefore, is to analyze and compare alternative solutions and, at the same time, to test the sensitivity of the model's results to variations in key parameters, particularly those which were not estimated from a data base.

The chapter contains six sections and one appendix. Section 7.1 analyzes energy-labour force interactions by changing the elasticities of substitution between primary inputs through CES production functions. Section 7.2 examines the sensitivity of the optimal path to different world oil price expectations. The response of the model when the ceiling on oil production levels is relaxed is described in section 7.3. Section 7.4 refers to the parameters of the ELES and is composed of two sets of experiments: the first run modifies the rate of time preference, while the second changes the value of the marginal expenditure shares so as to assess the impact of variations in the domestic demand for energy. Section 7.5 studies the sensitivity of the model's results to alternative weights on terminal assets. The final section focuses on energy-foreign debt interactions by evaluating the effects on the optimal solution of more favourable external debt conditions: firstly, a reduction in the initial external debt level is imposed, and then, a fall in the real interest rate on foreign debt is assumed, together with an increase in oil prices. Finally, the appendix of this chapter presents three sets of Tables for each one of the above experiments: (A) Macroeconomic Results; (B) Gross Output Levels; and (C) Shadow Prices.

7.1 Sensitivity to Alternative Elasticities of Substitution.

One of the main purposes of this work is to examine energy-labour force interactions; specifically, to evaluate the impact of skilled labour force restrictions on the optimal growth path in general, and in particular on the ability of the economy to absorb oil revenues. In the Base Run, an unitary elasticity of substitution between capital and labour through C-D production functions was assumed, which meant full employment of the three labour categories. In order then to evaluate the sensitivity of the optimal path to variations in the elasticity of substitution and to allow for the possibility of unemployment in the model, the C-D technology is replaced by nested CES production functions.

Now, given that this work is interested in assessing skilled labour restrictions on the economy, rural and urban unskilled labour are aggregated into one composite category called total unskilled labour [1]. Thus, in a first level of CES production functions, total unskilled labour is combined with urban skilled labour to determine the total demand for labour. The resulting demand for labour is then combined with capital in a second level of CES functions to generate value added for all sectors [2]. These two CES production function levels are specified in the same way in all 13 sectors [3]:

$$(1)\quad L_{i,t} = \bar{F}_i \left[\beta LS_{i,t}^{-\rho_i} + (1-\beta)\, LU_{i,t}^{-\rho_i}\right]^{-1/\rho_i}$$

where:

$L_{i,t}$ = Total demand for labour by sector i, year t.
$LS_{i,t}$ = Demand for skilled labour by sector i, year t.
$LU_{i,t}$ = Demand for unskilled labour by sector i, year t.
$\bar{F}_i$ = Efficiency parameter by sector i.
β = Distribution parameter ($0\leq\beta<1$).
ρ_i = Substitution parameter ($-1<\rho<\infty$).

$$(2)\quad X_{i,t} = \bar{A}_i \left[\delta K_{i,t}^{-\rho_i} + (1-\delta)\, L_{i,t}^{-\rho_i}\right]^{-1/\rho_i}$$

where:

$X_{i,t}$ = Gross Output by sector i, year t.
$K_{i,t}$ = Capital stock by sector i, year t.
$\bar{A}_i$ = Efficiency parameter by sector i.
δ = Distribution parameter ($0\leq\delta<1$).
ρ_i = Substitution parameter ($-1<\rho<\infty$).

---

[1] Reducing the number of labour categories from three to two also simplified greatly the solution of the model.
[2] For an analysis about aggregation of labour inputs with a two-level CES function see Bowles (1986).
[3] Recall that the remaining factors of production: intermediate inputs and noncompetitive imports are assumed to be strictly complementary so that they are determined through Leontief functions, and that the availability of each skill group is projected exogenously.

The efficiency and distribution parameters are calculated directly from the 1980 I-O Table [4], whereas the substitution parameters are estimated independently. As is well known, ρ determines the elasticity of substitution since $\sigma = 1/1+\rho$. Although the CES technology restricts σ to constancy, it permits a much wider choice among alternative values. Unfortunately, there is, in general, a lack of reliable estimates for the elasticities of substitution between primary inputs for the case of Mexico. However, it was possible to generate some "guesstimates" about their value. For example, the C-D's $\sigma=1$ (i.e. $\rho=0$) is considered as a high elasticity value because it does not require a minimum skilled labour to output ratio. Thus, overall, the elasticities of substitution are specified below unity so as to make it possible for skilled shortages to restrict output. Also, intuition suggests that sectors which are intensive users of skilled labour (e.g. oil related industries), have a relatively low substitutability between either skill and unskilled labour or between capital and labour, whereas sectors such as agriculture and construction should be given higher elasticity values. Several alternative experiments were carried out with different elasticity values but this subsection shall report only the results obtained assuming the elasticities shown in Table 7.1.

---

[4] The efficiency and distribution parameters are subject to calibration to ensure that the model's total production per sector is identical to the benchmark values.

Table 7.1
Substitution Elasticities Used
in Sensitivity Analysis Experiments.

Sector	Unskilled/ Skilled Labour	Capital/ Labour
Agriculture	0.60	0.50
Mining	0.30	0.20
Oil and gas	0.10	0.10
Refining	0.10	0.10
Petrochemicals	0.10	0.10
Man. Capital	0.33	0.33
Man. Rest	0.33	0.33
Construction	0.70	0.60
Electricity	0.10	0.10
Transport	0.30	0.20
Commerce	0.40	0.30
Services	0.60	0.50
Government	0.30	0.20

Nested CES production functions with such elasticities of substitution leads to unemployment of unskilled labour throughout the model's horizon. Table 7.2 shows that in 1984-2004, the annual employment rate of growth for total unskilled labour is 2.5 percent, against 3.7 percent obtained with a C-D technology (average of 3.6 for rural and 3.8 for urban unskilled), which is also equivalent to the exogenous labour supply projections. Consequently, the interplan annual unemployment growth rate is 6.4 percent for total unskilled labour. Overall, total unemployment as proportion of the labour force increases from 16.5 percent in 1984 to 28.5 percent at the end of the plan period [5].

[5] In 1986, the rate of open unemployment was estimated at 17.6 percent (SHCP, 1986).

Table 7.2
Employment and Unemployment
by Labour Categories, 1984-2004.
(Millions of Persons)

Category	1984	1988	1992	1996	2000	2004	[%][1]
I. Labour Force Projections:							
(a) Unskilled	14.8	17.6	20.4	23.6	27.3	31.5	3.8
(b) Skilled	10.1	11.6	13.2	15.1	17.3	19.7	3.4
(c) Total	24.9	29.2	33.6	38.7	44.6	51.2	3.6
II. Employment:							
(a) Unskilled	10.7	12.4	13.7	16.0	17.3	17.4	2.5
(b) Skilled	10.1	11.6	13.2	15.1	17.3	19.7	3.4
(c) Total	20.8	24.0	26.9	31.1	34.6	37.1	2.9
III Unemployment:							
(a) Unskilled	4.1	5.2	6.7	7.6	10.0	14.1	6.4
(b) Skilled	0.0	0.0	0.0	0.0	0.0	0.0	-
(c) Total	4.1	5.2	6.7	7.6	10.0	14.1	6.4
Tot Unemp./ Tot. L.Force	16.5	17.8	19.9	19.6	22.4	27.5	2.6

[1] Average annual rate of growth, 1984-2004.

This Table also shows that there is full employment of skilled labour during all time periods, that is, the economy is restricted by the exogenous amount of skilled labour that is specified in the model throughout the model's plan horizon.

Some of the consequences of skill labour shortages on the economy can be seen in Table 7.3, where the main macroeconomic variables grow at lower rates than in the case when a C-D technology is assumed.

Table 7.3
Impact of Different Elasticities of Substitution on Main Macroeconomic Aggregates, 1980-2004 [1].

Period	GDP $\sigma=1$	GDP $\sigma<1$	Consumption $\sigma=1$	Consumption $\sigma<1$	Investment $\sigma=1$	Investment $\sigma<1$
1980-1984	1.4	-0.7	4.0	1.9	3.7	1.1
1984-1988	2.4	1.9	3.1	2.4	-4.1	-4.3
1988-1992	4.0	3.1	3.6	2.7	0.5	0.3
1992-1996	4.7	4.4	3.5	3.0	3.7	2.4
1996-2000	2.3	2.2	2.0	1.7	0.6	0.5
2000-2004	1.7	1.7	1.5	1.8	3.5	2.8
1980-2004	2.7	2.1	2.9	2.3	1.3	0.4

[1] Average annual growth rates.

The overall annual GDP growth is now not only below the labour force growth, but it is also inferior population growth (estimated at 2.3 percent). Similarly, consumption is consistently below Base figures and in some periods the difference is more than two percentage points. Yet the most unfavourable impact of skill restrictions is on investment expenditures. As Figure 7.1 depicts, investment is about 18 percent below Base values towards the end of the planning period, which suggests that those investment projects that are skilled labour intensive have been affected. Analyzing this result in greater detail, Figure 7.2 describes that the investment expenditures allocated to a weighted average of skilled labour intensive industries such as petrochemicals and refining [6], suffered a decline relative to the Base Run, which is ultimately reflected in low sectorial output levels. For instance, the interplan annual growth rates of

[6] THe weights of Figure 7.2 are given by the shares on the skilled labour per value added ratio using 1980 I-O and employment data. For example, the most skilled labour intensive industry is petrochemicals with 15.4 percent of the total followed by refining and electricity with 14.4 and 11.8 percent, respectively. On the bottom of the list come agriculture and commerce with 1.8 and 1.2 percent in that order.

Figure 7.1

Investment Under Alternative Elasticities of Substitution.

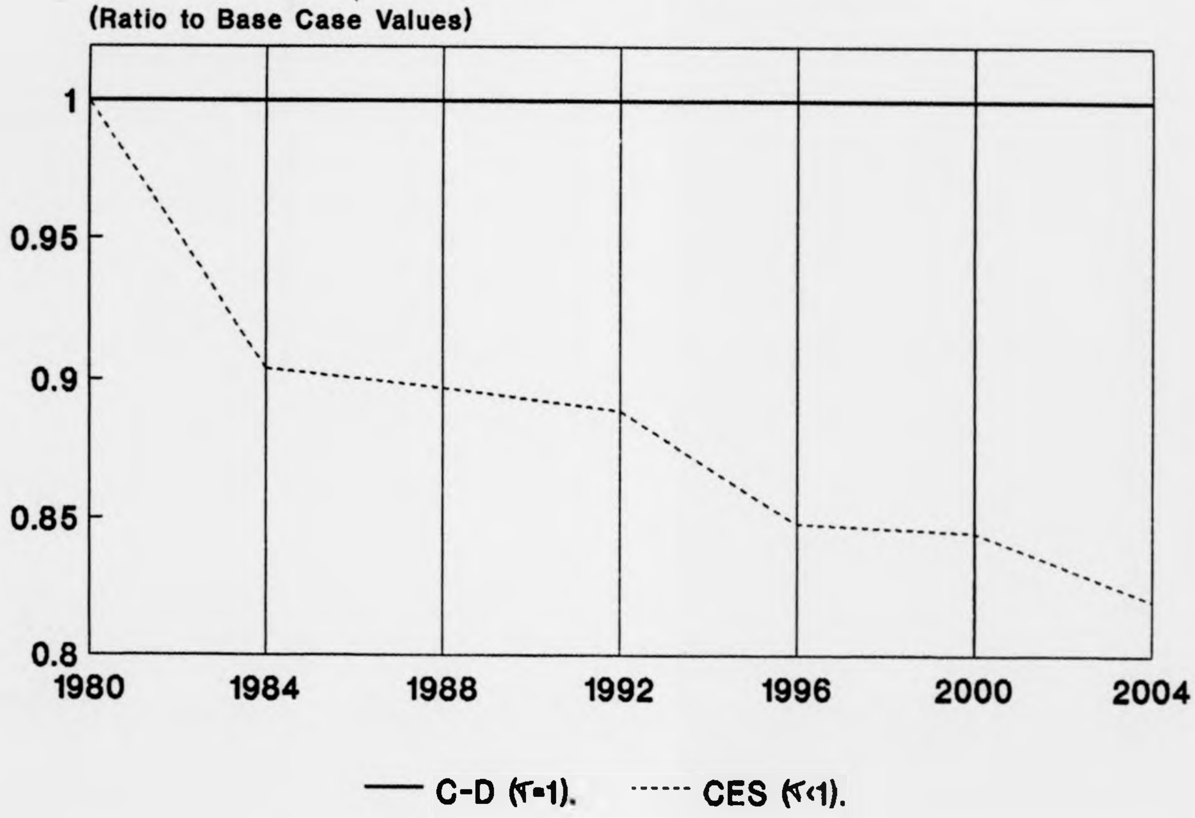
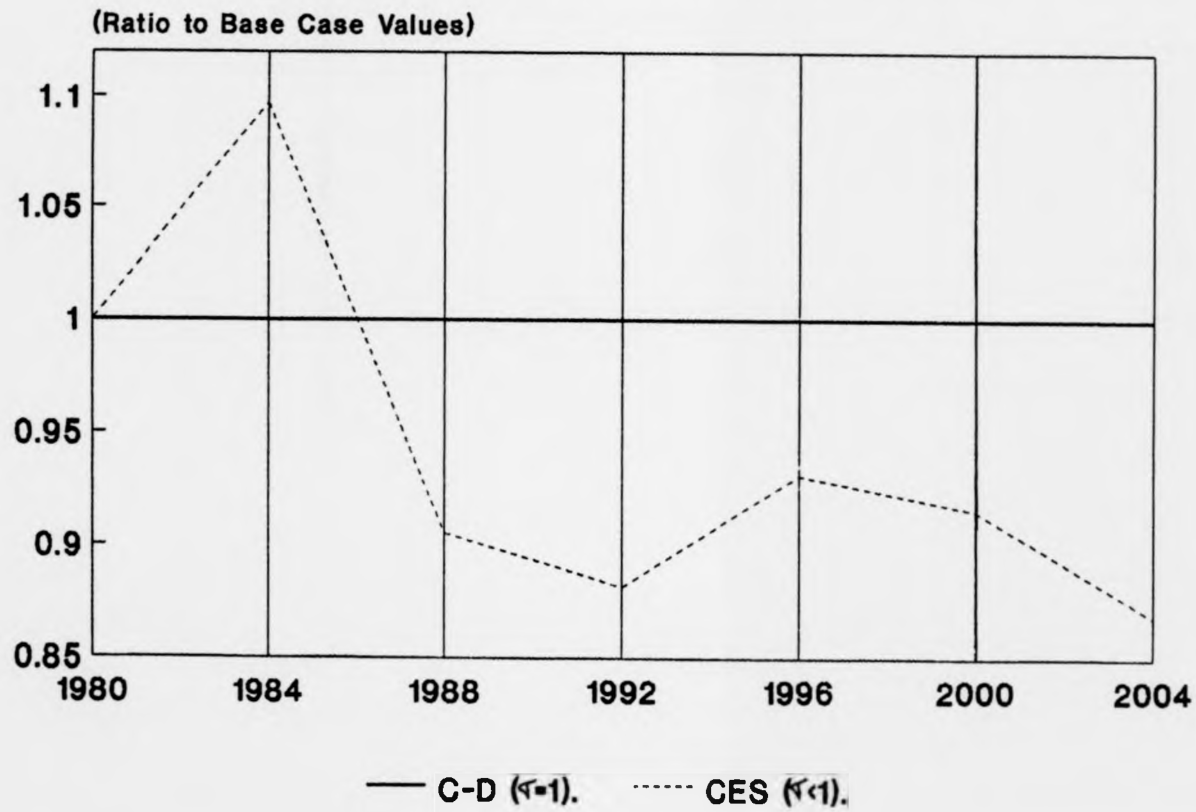


Figure 7.2

**Investment of Skilled L. Intensive Ind.
Under Different Substitution Elast.**



petrochemicals, refining and electricity fell from 3.1, 5.5, and 5.4 percent, respectively, to 2.4, 4.3, and 4.7 percent (see the Gross Output Table in the appendix).

Moving now to broad sectorial performance, Table 7.4 describes a transition of the economy towards an increase in the production of tradeables relative to both NT and oil related sectors, that is similar to the structural adjustment process seen in the Reference Case. The difference is that the deviation from balanced growth (ratio of production of tradeables over NT) is now most pronounced in the 1988-1992 period (instead of 1984-88), when NT show a decline of 0.6 percent in their average growth and tradeables grow at an even faster rate than in the Base Run.

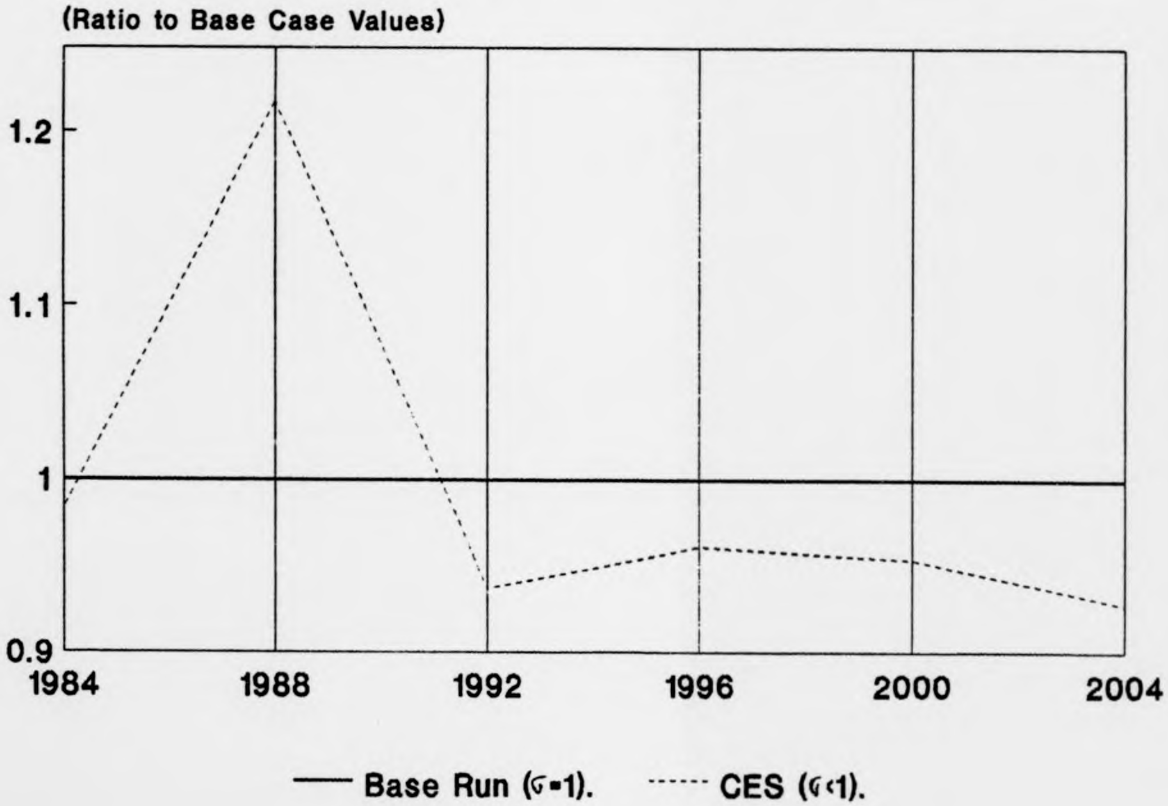
Table 7.4
Impact of Alternative Elasticities of Substitution
on Weighted Annual Sectorial Growth Rates, 1980-2004.

	C-D (σ=1)			CES (σ<1)		
Period	Traded	N-T	Oil	Traded	N-T	Oil
1980-1984	6.5	8.2	8.5	3.6	4.3	6.6
1984-1988	5.3	2.9	0.5	4.8	7.9	-1.3
1988-1992	5.2	3.1	5.0	7.9	-0.6	4.5
1992-1996	4.0	1.3	3.4	5.4	3.2	3.4
1996-2000	3.5	1.1	2.4	3.7	1.2	2.3
2000-2004	1.6	0.7	2.3	1.7	0.3	2.0
1980-2004	4.4	2.9	3.7	4.5	2.7	2.9

This transition is also reflected in the shadow prices of the model. Computing the internal real exchange rate (PNT/PT) and comparing it to the corresponding relative price of the Base Run, Figure 7.3 reports an appreciation in the 1984-92 period because now the structural adjustment process is relatively less dramatic than in the Base

Figure 7.3

Internal Real Exchange Rate Under Different Elasticities of Substitution.



Price of Nontradeables / Tradeables.

scenario, but otherwise this relative price adjustment is even more favourable towards tradeable industries.

Regarding the second important shadow price, the real wage, the shadow prices for skilled labour are positive throughout (i.e. there is full employment), whereas the optimal solution of the system is not binding with respect to unskilled labour, so that their shadow prices are set at zero in all time periods. In this experiment then, it is not possible to compute the efficiency price differentials between labour categories as was done for the Base Run. However, the shadow price of urban skilled labour can be compared in both cases: assuming C-D and CES production functions with $\sigma<1$. This is done in Table 7.5 below.

Table 7.5
Shadow Price of Urban Skilled Labour Under Different Elasticities of Substitution, 1984-2004.

Year	C-D ($\sigma=1$) Absolute	Relative [1]	CES ($\sigma<1$) Absolute	Relative [1]	CES/ C-D
1984	4.094	0.175	7.171	0.239	1.8
1988	2.895	0.160	5.831	0.226	2.0
1992	1.507	0.149	3.130	0.221	2.1
1996	0.810	0.143	1.446	0.208	1.8
2000	0.433	0.140	0.710	0.201	1.6
2004	0.310	0.122	0.436	0.123	1.4

[1] Shadow price of urban skilled labour relative to the cost of foreign exchange.

As expected, Table 7.5 indicates that the intertemporal shadow prices for skilled labour in absolute terms are greater for the case when the elasticity of substitution between skill groups is below one. In other words, the objective function would increase by a greater amount if there was an extra skill worker when $\sigma<1$ is assumed, than when $\sigma=1$ is employed. The skill shadow prices relative to the cost of foreign exchange show the same result: skill labour is more valuable compared to foreign exchange when a minimum skill labour to output ratio is required. Notice also that in both cases the skill labour restrictions diminish as time passes, indicating that it is preferable to have an extra worker sooner rather than later.

Despite the fact that the economy in general appears to be constrained by skill labour shortages, the system is not restricted in its ability to absorb oil revenues. In effect, optimal extraction levels are equal to the upper bounds in all time periods, and thus, oil and gas output is exactly the same as in the Base Run (see Table B of the appendix). Also, in spite of the change in production technology, the model still chooses to reduce the level of accumulated foreign debt by making principal payments from 1984 onwards. On this occasion, however, total accumulated debt payments amount to 603.1 bp (instead of 909.0 bp in the Base Run), so that accumulated foreign debt burden is 1643.1 bp against 1337.2 bp of the Reference Case (see Table A of this experiment in the appendix). Of course, the reduction in the "accumulation" of foreign assets is, as in the case of the decline in the accumulation of real capital assets, the reflection of a more tight overall economic situation in relation to the full employment scenario.

To sum up the results of this section, elasticities of substitution below one add an additional constraint to the system: the economy is now restricted by skill labour shortages, whereas there is unemployment of the least skilled labour groups throughout. This in turn calls for lower rates of growth of the main macroeconomic variables, as well as for more depressed sectorial output growth than in the Base Run. Yet, some of the important results of the Reference Case are maintained:

- Both the real and dual sides of the model capture a structural adjustment process towards expansion of nonoil tradeable producing industries.

- Oil and gas extraction levels are set equal to the production ceilings throughout.

- Foreign exchange is the most serious constraint of the system, so that foreign debt reduction is considered as the most profitable way of allocating current income.

7.2 Sensitivity to Alternative Oil Price Expectations.

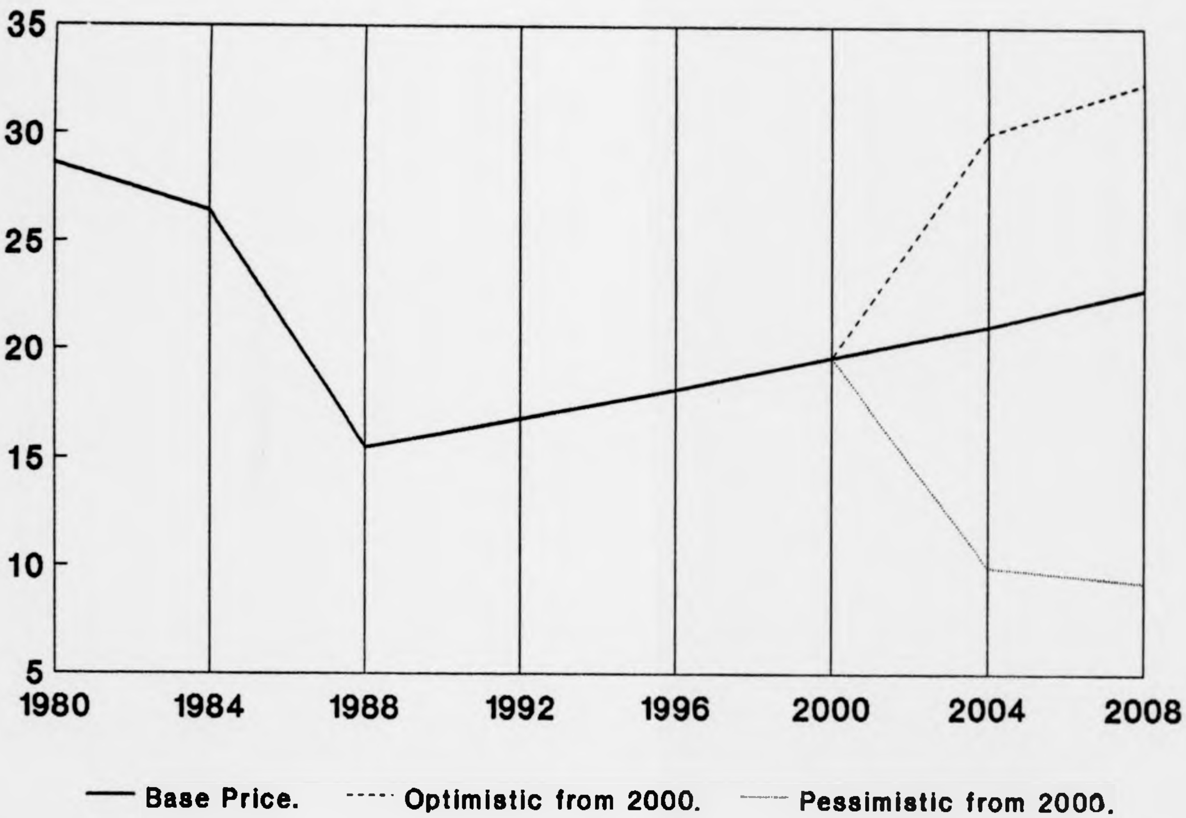
It is clear that the pattern of future oil prices has an influence on the nature of the optimal growth path of the model. Now, the expectations of future world oil prices can be synthesized into two basic ingredients (Dasgupta and Heal, Ch. 15): the trend of past prices and some index of the balance between the remaining stock of the resource and future demand for it. This index, of course, depends on a multitude of factors such as: worldwide discovery rates, worldwide economic growth, technological developments affecting other forms of energy (solar, nuclear, biomass, etc.) conservation and domestic price policies and political developments of various sorts affecting the production and worldwide trade of hydrocarbons. All these factors could combine to drive the barrel of oil steadily up in value. On the other hand, the combination of a series of technological breakthroughs, major new discoveries and slow economic growth in the leading consuming nations could lead to declining prices.

Hence, traders have to rely on their expectations of future prices in deciding how fast to deplete and are faced with unavoidable uncertainty about future revenues. Explicit incorporation of that uncertainty in the optimization process is not one of the purposes of this work, and is therefore not attempted here. However, in order to explore the sensitivity of the optimal growth path to variations in the assumptions about future oil prices, several experiments were conducted, two of which are reported next as alternative scenarios to the Base Run. In both runs, oil prices follow the same pattern as in the Reference Case until the year 2000. In the last period of the model, however, the optimistic scenario assumes, on the one hand, that oil prices jump from $19.6 per barrel in the year 2000 to $30 per barrel four years later (instead of $21.1 in the Base Run), while the pessimistic case assumes that oil prices fall in the year 2004 to $10 per barrel (see Figure 7.4). The remaining assumptions of the Base Case are kept the same including the upper limits on oil extraction [7]. In this case it is important to recall an earlier feature of the model. Because of its nature, the changes imposed in oil prices are perfectly foreseen by the model, implying that an

[7] Of course, the different assumptions about the oil price also affect the terminal price of hydrocarbon reserves placed in the objective function. In the optimistic case, the premium for holding oil and gas underground increases as the 2008 price of oil (undiscounted) is $32.4 per barrel instead of $22.8 assumed in the Base Run and $9.3 in the pessimistic case (see again Figure 7.4).

Figure 7.4

Alternative Oil Price Scenarios.
(US$/barrel)



optimal adjustment can be made before the change actually takes place.

Despite the differences in terms of oil price expectations, optimal oil extraction is set at the maximum levels in both alternative runs and the only difference in terms of the behaviour of the oil and gas sector refers to the oil revenues that are generated with each oil price pattern. Nevertheless, in the pessimistic case, with the collapse of oil prices at the end of the horizon, more production of tradeable goods, both exportables and import substituting, are required to compensate for lower oil revenues. Table 7.6 shows that the weighted annual growth rate of the tradeable sector increases somewhat compared to the Base Run even before the fall in oil prices (reflecting the adjustments made in anticipation to such fall), but particularly during 2000-2004; while the opposite occurs with the growth of the NT sector.

Table 7.6
The Impact of Alternative Oil Price Scenarios on Annual Sectorial Growth Rates, 1980-2004.
(Percentages)

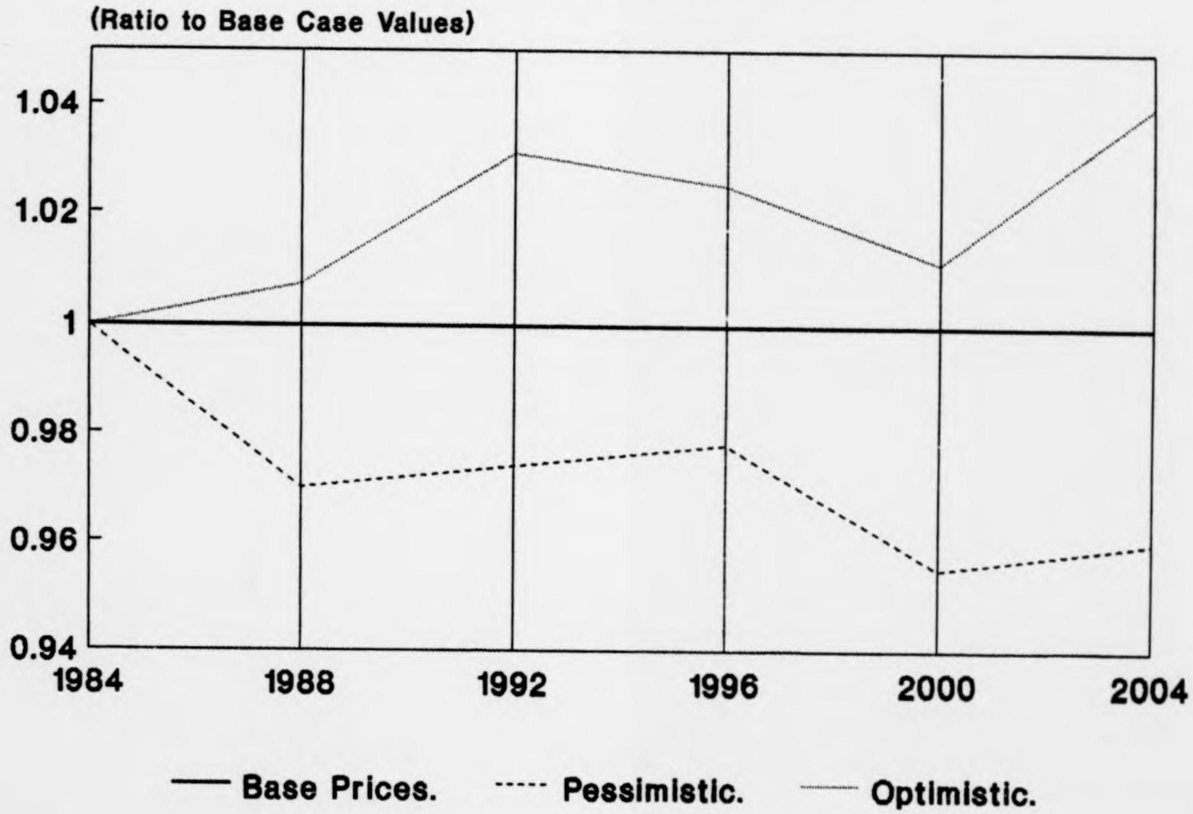
	Tradeables:			Nontradeables:		
Period	Base	Opt.	Pess.	Base	Opt.	Pess.
1980-1984	6.5	6.4	6.5	8.2	8.3	8.2
1984-1988	5.3	5.2	5.4	2.9	3.0	2.8
1988-1992	5.2	5.2	5.3	3.1	3.2	3.1
1992-1996	4.0	3.9	4.2	1.3	1.5	1.2
1996-2000	3.5	3.4	3.7	1.1	1.3	0.9
2000-2004	1.6	0.8	2.3	0.7	1.1	0.4
1980-2004	4.4	4.3	4.5	2.9	3.0	2.8

The above results for the pessimistic oil price scenario call for a slight increase in the real depreciation of the internal exchange rate (price of NT vis-a-vis tradeable goods) in all time periods, in comparison to the Base Run (see Figure 7.5). This indicates that traded goods in general are becoming more expensive relative to NT goods, basically because the manufacturing goods required to meet the external commitments are dearer, given the loss in oil revenues. Clearly, Figure 7.5 argues for a shift of resources out of NT into the tradeables sectors. Specifically, an increase in the share of traded goods in terms of capital is required since this sector is relatively capital intensive. This explains the fact that the composition of investment is now even more favourable of capital in the non-oil traded goods sector as depicted in Figure 7.6, where investment is more than 4 percent above the Base values towards the end of the model's horizon. Even so, the effort is not enough to compensate for the collapse in oil export earnings so that GDP growth is even lower than in the Reference Case. Figure 7.7 describes the impact of alternative oil price scenarios on the performance of gross output as proportion to the Base Run. Moreover, the reduction in oil revenues also has a significant impact on real consumption, which can be taken as our welfare indicator. As Figure 7.8 indicates, real consumption is 2.2 percent below its Base values at the end of the plan period.

The optimistic oil price scenario, on the other hand, indicates that most macroeconomic variables are set at slightly higher levels compared with the other two cases, including GDP and consumption as seen in Figures 7.7 and 7.8. This scenario also reduces, to a certain extent, the

Figure 7.5

Internal Real Exchange Rate Under Different Oil Price Scenarios.



Price of Nontradeables / Tradeables.

Figure 7.6

Investment in the Tradeable Sectors Under Different Oil Price Scenarios.

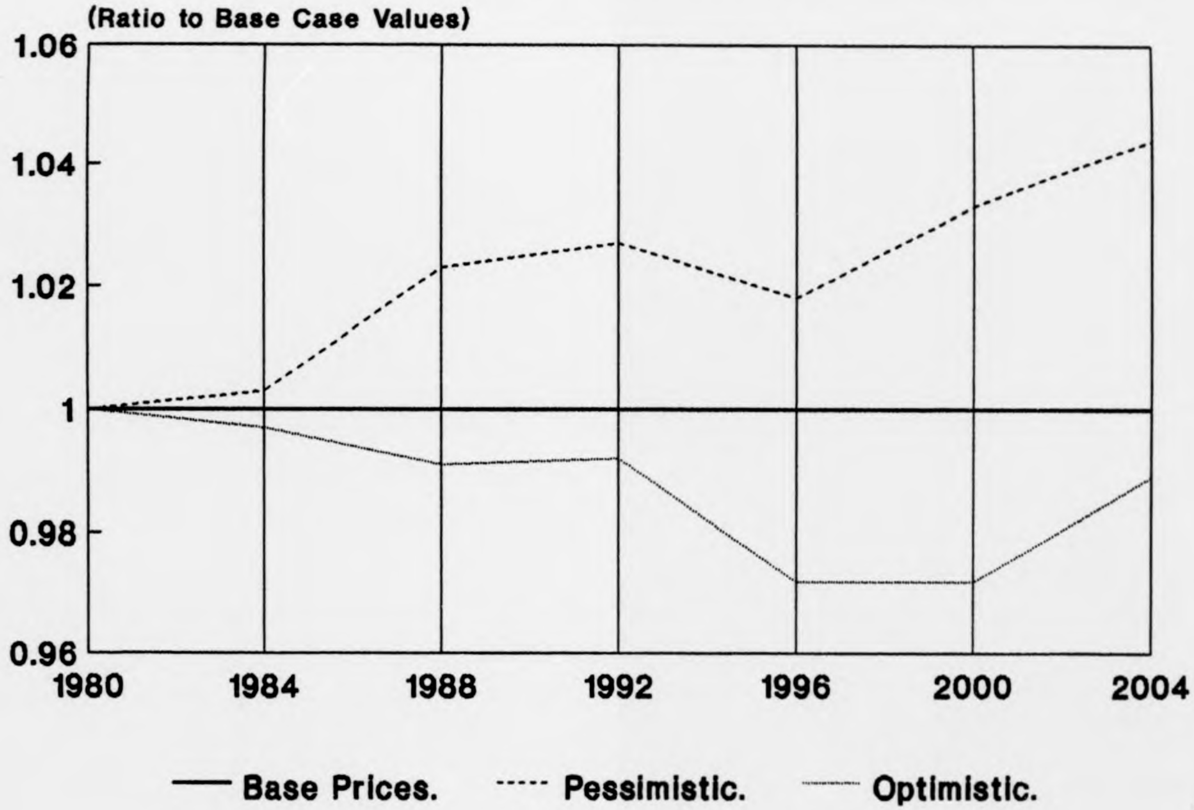


Figure 7 .7

GDP Under Alternative
Oil Price Scenarios.

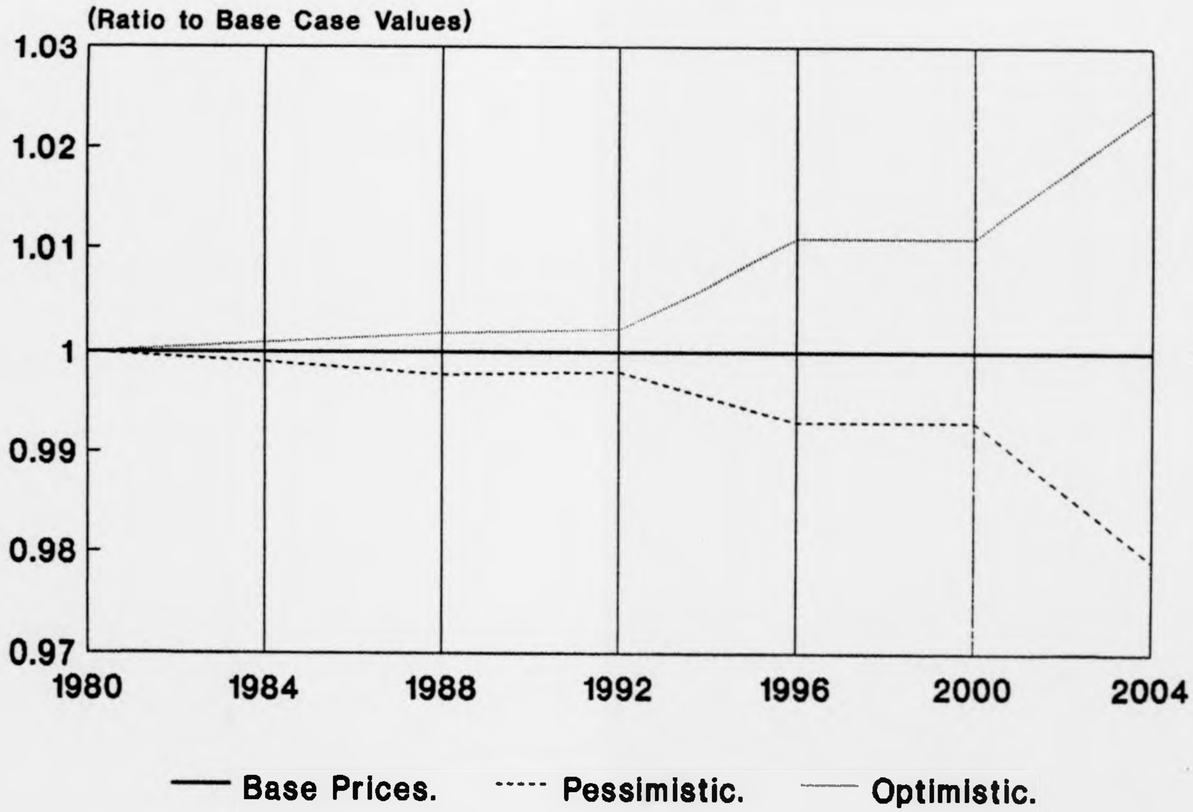
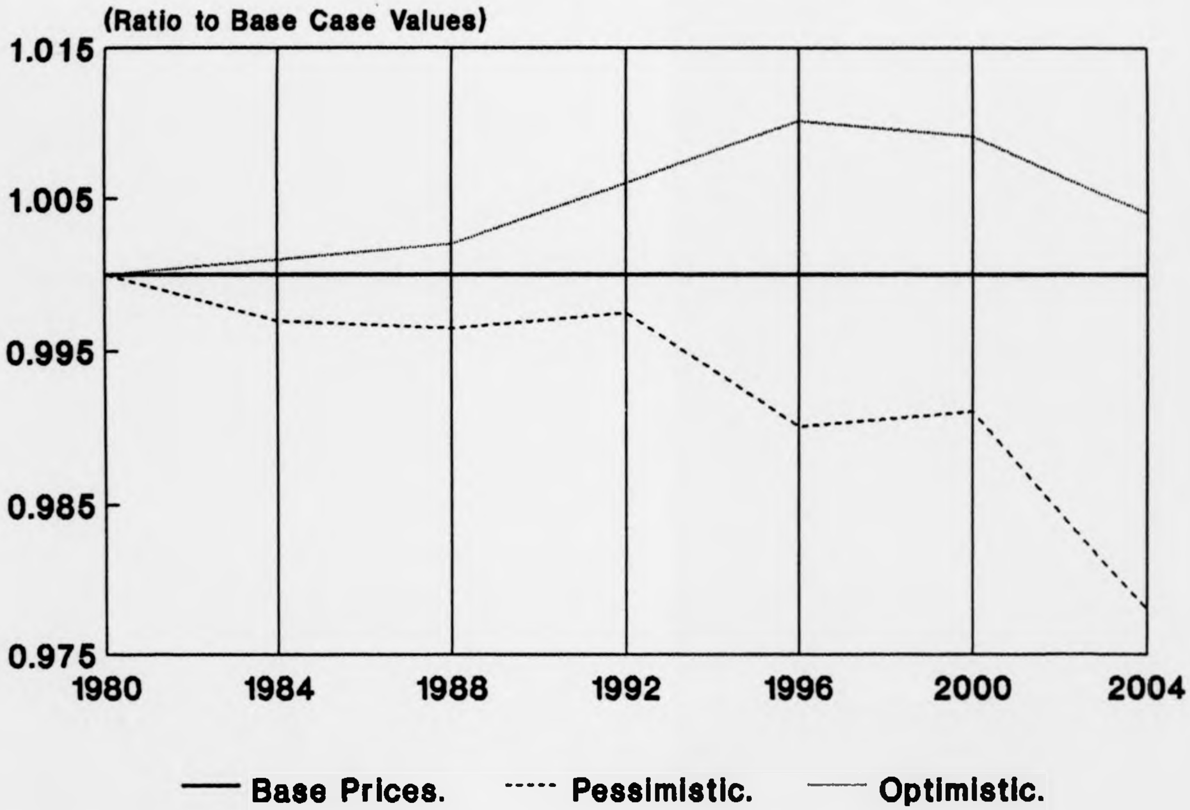


Figure 7.8

Consumption Under Different Oil Price Scenarios.



need for rapid growth in the non-oil tradeable sectors, which is reflected in a lower allocation of the capital stock to the tradeable sectors in relation to the two other cases as Figure 7.6 implies. Also, given that the terms of trade deteriorate less in the optimistic case during the last period of the model, the external exchange rate (price of domestic goods over imports) is appreciated about 10 percent relative to the Reference Case (see the aggregate consumption row of the shadow prices Table presented in the appendix).

The big jump in oil prices makes oil revenues increase their share in total exports from 15.9 percent in the Base Run to 21.3 percent at the end of the model's horizon (see Table A of the appendix). The additional foreign exchange revenues of the optimistic case [8] enable the economy to make more principal payments: in the year 2004, the reduction in foreign debt amounts to 214.4 billions of pesos (bp) instead of 151 bp of the Base Run [9]. Thus, despite a substantial increase in the premium for holding oil and gas underground, the most profitable way of allocating current income still consists in "decumulating" foreign debt. This result also explains in part why in this optimistic case the increase in GDP, consumption, investment and other macro variables appears to be quite modest in comparison to the Reference Case.

---

[8] Total accumulated oil export revenues amount to 1522.6 billions of pesos (bp) assuming the optimistic oil price pattern, that is, 129.8 and 188.6 bp in excess of the revenues obtained with the Base and pessimistic scenarios, respectively.

[9] During earlier periods, debt reduction is only slightly superior to the Base values.

7.3 Sensitivity to Alternative Oil Production Ceilings.

In the previous set of experiments the upper bound on oil extraction was not modified from the Base Run assumptions, and, as was just seen, optimal oil and gas extraction was set at the maximum levels despite the contrasting oil price projections. In the following set of experiments, the sensitivity of the optimal path was tested when the ceiling imposed by the government on oil depletion is relaxed. The pattern of oil prices, energy expenditure shares, hydrocarbons reserves and remaining assumptions are identical to the Base scenario.

As expected, when the upper bound on oil and gas production is raised, the optimal solution takes advantage of it and sets crude production at the maximum levels in all time periods, despite a reduction in the level of proven reserves. This result was held until the ceiling was increased to 2,900 millions of barrels (mb) at the end of the year 2004 (see Table 7.7), when Mexico would run out of hydrocarbons reserves in less than 13 years.

Table 7.7
Alternative Oil Production Ceilings, 1984-2004.
(Millions of Barrels)

Year	Base Run: Ceiling (1)	Base Run: Reserves (2)	Base Run: Years (2/1)	Maximum: Ceiling (1)	Maximum: Reserves (2)	Maximum: Years (2/1)
1984*	1393	71750	51.5	1393	71750	51.5
1988	1256*	71750*	57.1*	1800	71750	39.9
1992	1396	66725	47.8	2100	64450	30.7
1996	1552	61141	39.4	2400	56150	23.4
2000	1676	54935	32.8	2650	46550	17.6
2004	1776	48233	27.2	2900	35950	12.4

* Observed values. Source: Pemex (1988).

However, if the ceiling on the right of this Table is relaxed even further (to 3,000 mb in the year 2004), the optimal solution sets crude production at the maximum in only the first three periods of the model, and from there on oil extraction is significantly below the upper bounds. This indicates the point at which oil and gas reserves become a constraint of the system, unless, of course, new discoveries are made.

Now, the assumption of no new oil and gas discoveries from 1988 onwards seems very pessimistic given (i) the large investment effort in exploration that is underway (see Pemex, 1988), and (ii) past performance which has produced a constant stream of crude oil and gas discoveries. There is little doubt then that new proven hydrocarbons reserves will be found in Mexico and the uncertainty, in this case, relates only to the magnitude and time pattern of such discoveries. Yet, one of the important conclusions of this work is that even if these new proven reserves are ignored or do not materialize, the optimal pattern of oil and gas production is severely constrained with the fixing of production ceilings at the levels assumed in the Base Run, which are a rough extrapolation of recent conditions imposed by the authorities.

Of course, this result and the rest are crucially based on parameters whose future evolution we know very little about. Moreover, this model ignores Mexico's margin of manoeuvre abroad with respect to the oil market, that is, any attempt by Mexico to increase its participation in the share of the foreign market will affect the global conditions of the market and, in turn, the behaviour of the world market will influence Mexican possibilities and limitations in world oil matters. In other words, in spite of the magnitude of Mexico's oil and gas reserves, the country is not in a position to follow a completely autonomous oil policy, and it might well be the case that such an increase in oil depletion will prove to be infeasible.

Nevertheless, assuming that the government sets oil production ceilings at the levels described as "Maximum" in Table 7.7, and taking for granted that Mexico can in fact increase its share in the world market, the question is: is it worthwhile? Table 7.8 describes the sensitivity of the main macroeconomic aggregates to the two alternative oil production ceilings.

Table 7.8
Annual Growth Rates of the Main Macroeconomic Aggregates Under Different Oil Production Ceilings, 1980-2004.
(Percentages)

	GDP		Consumption		Investment		Oil Exports	
Period	Base	Max.	Base	Max.	Base	Max.	Base	Max.
1980-84	1.4	1.4	4.0	4.1	3.7	3.5	3.2	3.2
1984-88	2.4	3.2	3.1	3.2	-4.1	-3.9	-7.6	7.3
1988-92	4.0	4.1	3.6	3.6	0.5	0.7	2.1	4.3
1992-96	4.7	4.8	3.5	3.6	3.7	4.1	2.6	4.2
1996-00	2.3	2.5	2.0	2.1	0.6	1.7	1.2	3.1
2000-04	1.7	2.2	1.5	1.6	3.5	3.6	5.1	5.3
1980-04	2.7	3.0	2.9	3.0	1.3	1.6	1.0	4.6

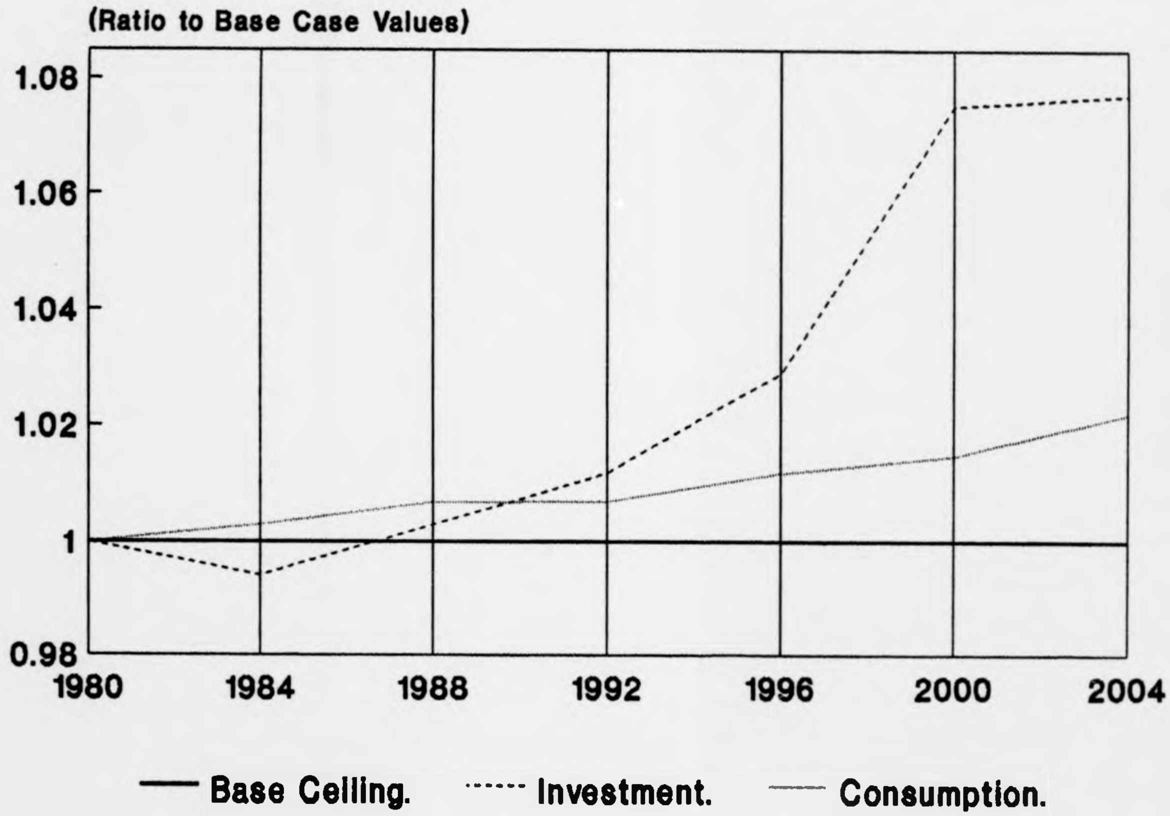
As can be seen in this Table, the economy is only able to grow at slightly higher rates than in the Base Run. In particular, despite the fact that the oil production ceiling is relaxed to the maximum allowed by the amount of available reserves, GDP growth is just 3.0 percent throughout. Also highlighted in Table 7.8 is the fact that increasing oil production has a more favourable impact on the accumulation of real capital assets than on consumption in relation to the Base Run. Figure 7.9 shows that investment expenditures increased more than 7 percent in proportion to the Base scenario (at the end of the period), while consumption is only 2 percent above.

This result can be explained by the fact that revenues from oil and gas imply decumulation of wealth unless they are converted into other productive assets. The Mexican economy, therefore, experiences a more pronounced portfolio switching effect than in the Reference Case: decumulation of oil and gas reserves not only is more severe but it also implies that a greater proportion of total wealth is now held in the form of real capital assets and, mainly, foreign assets. In effect, a big proportion of the extra oil revenue [10] goes to the retirement of foreign debt, so that the level of accumulated foreign debt at the end of the model's horizon falls from 1337.2 bp in the Base Case to 924.6 bp [11].

[10] Assuming the "maximum" ceiling, total accumulated oil export revenues (2687.4 bp) almost double the Base revenues (see the relevant Table in the Appendix).
[11] Obviously, the composition of exports is also modified. As can be seen in Table A of the Appendix, the shares of oil and manufacturing exports in the total at the end of the period are 31.0 and 61.5 percent, respectively, against 15.9 and 75.2 percent obtained in the Base Run. Notice also that the extra oil revenue enables the economy to transform the trade deficit into surplus by the end of 1992, instead of four years later as was the case in the Reference scenario.

Figure 7.9

Consumption and Investment Under Alternative Oil Production Ceilings.



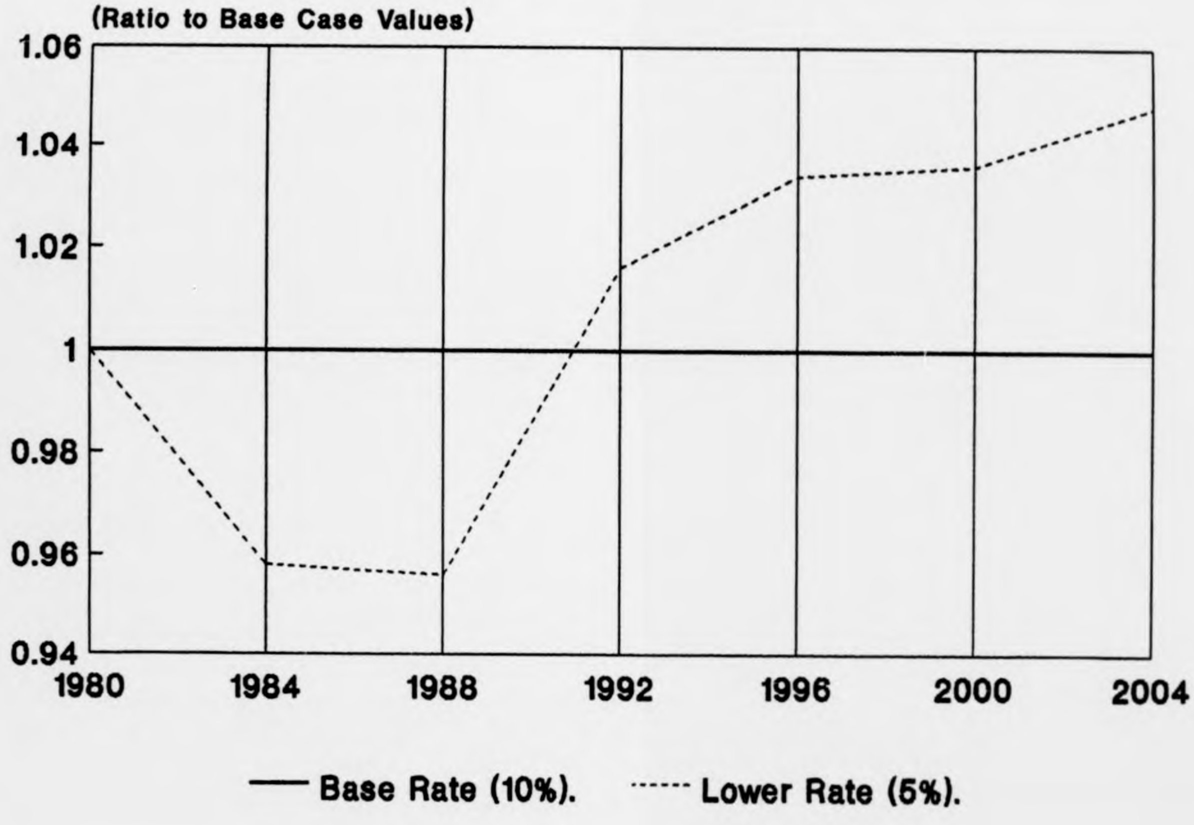
In sum, the model solution shows that if Mexico decides to deplete its hydrocarbons reserves more quickly, there would be some favourable effects on the performance of the economy, but even so the sacrifice would not be enough for the economy to achieve more than minimal rates of growth. Above all, the prospects for future generations could hardly be more depressing with insufficient investment in capital assets, oil and gas reserves almost depleted, and still, a considerable external debt burden.

7.4 Sensitivity to Alternative Utility Function Parameters.

Two sets of experiments are carried out regarding the parameters of the ELES. First, there is a run equal to the Reference case in all respects except for a lower rate of pure time preference (5 percent instead of 10 percent). Of course, the smaller this rate is, the less the future is discounted and, hence, the future is relatively more valuable. As theory would predict, a reduction in the discount rate means lower consumption initially (during the first two periods) and consistently higher consumption from there on compared to the Base Run, as can be seen in Figure 7.10 and Table 7.9. First period consumption is 4.2 percent below its Base value, whereas at the end of the year 2004 consumption is 4.8 percent higher. Similarly, as can be seen in Table 7.9 the annual rate of growth of GDP is below its Base values during earlier periods, while the opposite occurs in the second half of the model's horizon. Notice also that although the overall annual rate of GDP growth

Figure 7.10

Consumption Under Different Rates of Time Preference.



(2.9 percent) compares favourably against the 2.7 percent obtained with a higher discount rate, it would still be insufficient to absorb the growing labour force.

Table 7.9
Impact of Alternative Discount Rates on
GDP, Consumption and Investment Growth, 1980-2004.
(Percentages)

	GDP		Consumption		Investment	
Period	10%	5%	10%	5%	10%	5%
1980-1984	1.4	0.5	4.0	2.9	3.7	5.3
1984-1988	2.4	2.2	3.1	3.0	-4.1	-4.1
1988-1992	4.0	5.2	3.6	5.2	0.5	0.8
1992-1996	4.7	5.1	3.5	3.9	3.7	3.3
1996-2000	2.3	2.4	2.0	2.0	0.6	0.8
2000-2004	1.7	1.8	1.5	1.8	3.5	3.2
1980-2004	2.7	2.9	2.9	3.1	1.3	1.5

On the other hand, the lower rate of time preference also translates into a faster pace of capital accumulation than in the Base Run overall, with the consequent increase in capacity and growth. This includes the second period of the model which is when the foreign exchange constraint is at its maximum. During these years (1984-88) investment is about 6 percent above the Base Run value (see the relevant Table in the appendix), yet it also falls relative to the investment expenditures of the previous period as was the case in the Base Run.

In theory, a lower rate of time preference would also call for oil extraction to be shifted towards the future. However, given that the economy needs all the foreign exchange it can get in all time periods, and because oil production limits are always binding, optimal oil depletion pattern is once again equal to the upper bounds.

Turning now to sectorial output patterns, a lower discount rate also modifies the intertemporal growth rates of most sectors. With the exception of the oil and gas sector which, as stated before, is set at the maximum levels and of government services that are determined exogenously, the output of the remaining sectors are below Base values in the first two periods and above thereafter (see the Gross Output Levels Table in the appendix of this chapter). Despite these intertemporal changes, the capital goods manufacturing industry shows the highest rate of growth throughout, and construction output falls in 1984-88, as was the case in the Base Run.

Table 7.10 below presents the annual growth rates of the three broad sectors under the two alternative discount rates. In spite of the different assumptions about how much the future is discounted, both scenarios show similar structural adjustment processes towards expansion of export and import substituting activities.

Table 7.10
Impact of Alternative Discount Rates on Weighted Annual Sectorial Growth Rates, 1980-2004.
(Percentages)

	Base Run (10%)			Alternative Run (5%)		
Period	Traded	N-T	Oil	Traded	N-T	Oil
1980-1984	6.5	8.2	8.5	5.6	7.0	6.8
1984-1988	5.3	2.9	0.5	5.1	2.8	0.3
1988-1992	5.2	3.1	5.0	7.3	5.5	6.6
1992-1996	4.0	1.3	3.4	5.4	1.6	4.4
1996-2000	3.5	1.1	2.4	3.9	1.2	2.3
2000-2004	1.6	0.7	2.3	1.7	1.1	2.6
1980-2004	4.4	2.9	3.7	4.8	3.2	3.8

The second set of experiments regarding the parameters of the ELES consists in changing the value of the marginal expenditure shares in order to asses the sensitivity of the optimal path to variations in the domestic demand for energy. In a first run, that shall be called high domestic energy demand scenario, the marginal expenditure shares of energy-intensive products such as: refining, both manufacturing goods, transport and electricity are increased, while that of the other goods and services falls so that the sum of all the shares adds to one as can be seen in Table 7.11.

Table 7.11
Alternative Domestic Energy Demand Scenarios.

Product	Base Run*	High	Low
Agriculture	.093	.083	.103
Mining	.0001	.0001	.0001
Refining	.02401	.034	.0146
Man. Capital	.041	.051	.031
Man. Rest	.32059	.331	.300
Electricity	.016	.026	.010
Transport	.0659	.076	.0559
Commerce	.2494	.2294	.2694
Services	.190	.1695	.216
	1.0	1.0	1.0

* Source: Garcia Alba (1986).

The high domestic demand scenario tries to reflect the fact that in the recent past Mexico has experienced extraordinary high growth rates of domestic demand for energy. As was explained in section 2.1, traditionally domestic energy prices in Mexico have been set below world price levels, which together with the rapid economic growth and rapid urbanization of the last three decades [12] have meant an income elasticity of energy consumption expenditures which is greater than one.

As Table 7.12 makes clear, high domestic energy demand puts the economy under more stress relative to the Base Case, reducing the annual rates of economic growth during all time periods.

Table 7.12
Impact of Alternative Domestic Energy
Demand Scenarios on GDP Growth, 1980-2004.
(Percentages)

Period	Base	High	Low
1980-1984	1.4	1.2	1.7
1984-1988	2.4	2.3	2.5
1988-1992	4.0	3.9	4.1
1992-1996	4.7	4.5	4.6
1996-2000	2.3	2.0	2.4
2000-2004	1.7	1.2	1.9
1980-2004	2.7	2.5	2.9

Similarly, Figure 7.11 depicts a reduction in consumption of about 4 percent towards the end of the planning horizon in comparison with the Base Run. The large internal energy consumption requirements also calls for even more rapid growth in the ratio of production of tradeable to NT goods (see Figure 7.12). This is also reflected in the valuation side of the model: Figure 7.13 indicates that the internal real exchange rate has to depreciate slightly more than in the Reference Case so as to facilitate substitution, away from traded goods in consumption and towards them in production.

[12] In 1986 about 65 percent of total population lived in urban areas according to World Report, 1988.

Figure 7.11

Consumption Under Alternative Domestic Energy Demand Scenarios.

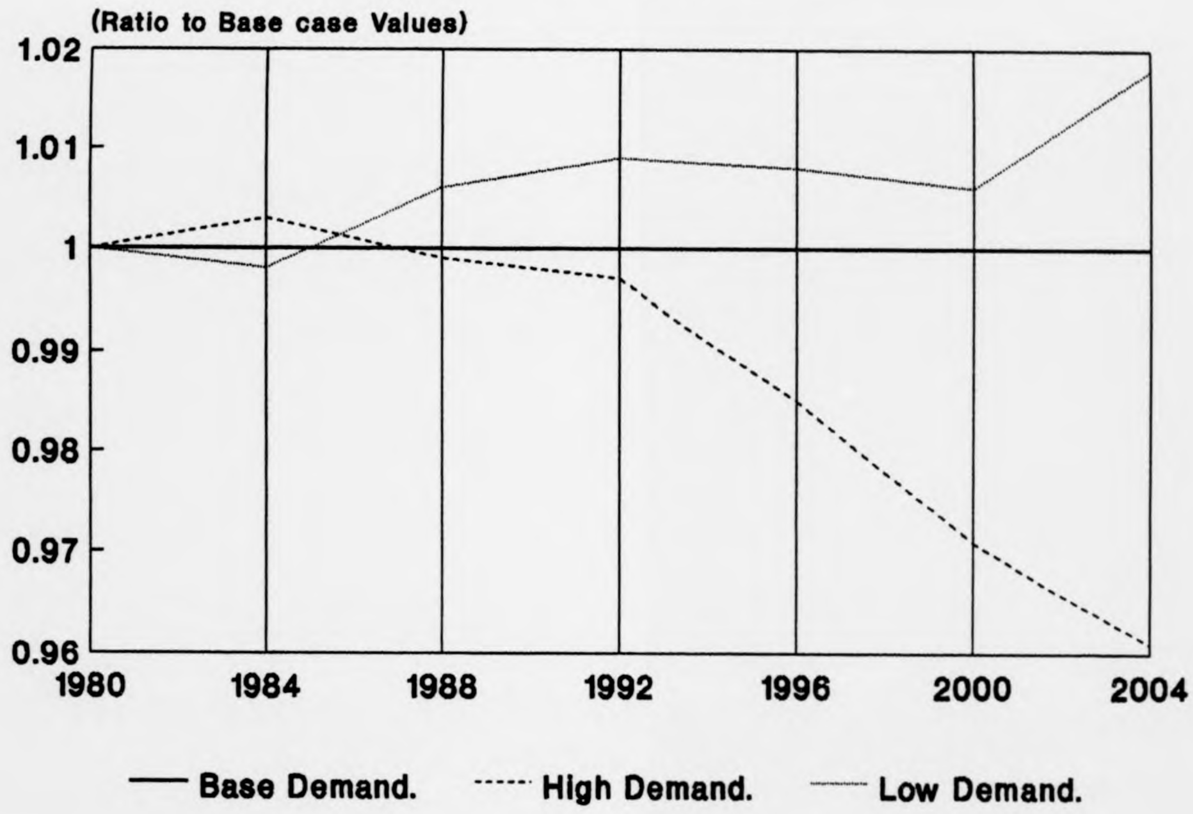


Figure 7.12

Impact of Alternative Domestic Energy Demand Scenarios on Sectoral Output.

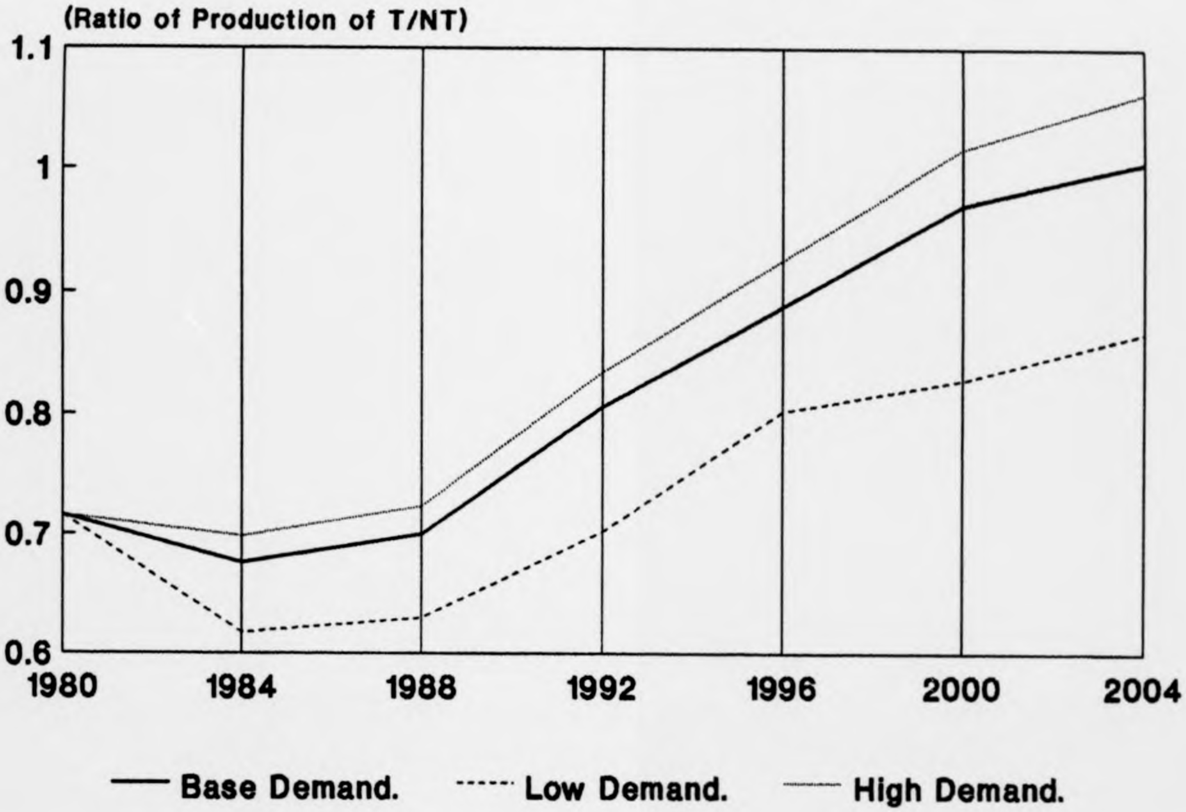
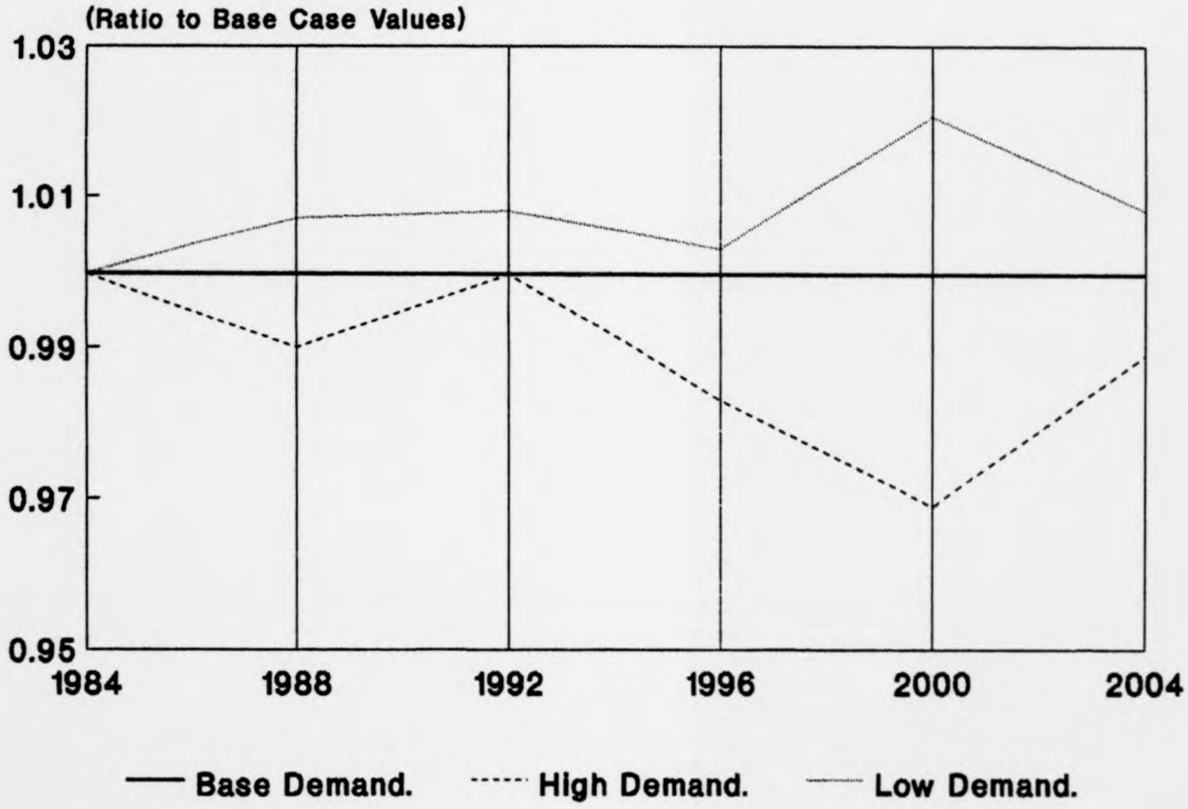


Figure 7.13 **Real Exchange Rate Under Different Domestic Energy Demand Scenarios.**



Internal Ex. Rate (PNT/PT).

Turning now to oil matters, the effect in increasing domestic energy consumption is to reduce the amount of crude oil and gas that is available for export (see Figure 7.14). Overall, the reduction in oil export earnings amounts to 352.8 bp as compared to the Base Run, and to 289.0 bp relative to the case where oil prices drop to $10 per barrel seen in section 7.2. This result then, makes the important point that domestic energy consumption (both in industry and consumption), and exports are competitors for Mexico's oil production if, in fact, limits are set on that production.

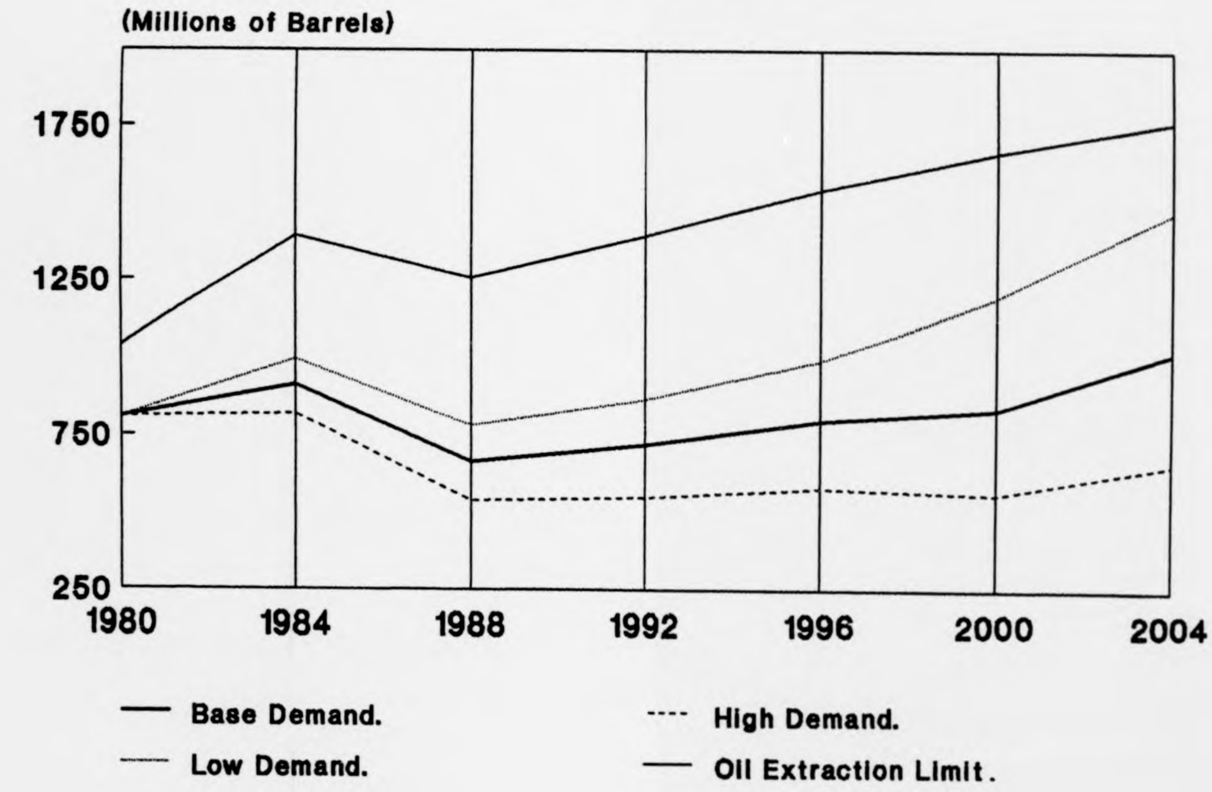
In an opposite case: low domestic energy consumption, the marginal expenditure shares of energy intensive products is reduced to the levels described in Table 7.11, so as to reflect the fact that, recently, Mexican authorities have been trying to improve the energy efficiency of the domestic economy, and domestic prices are moving in line with international prices (see Section 2.1). It is likely, therefore, that the future will be characterized by more moderate domestic energy consumption, as implicit in the low energy demand scenario.

Reduction in the domestic demand for energy has favourable effects throughout the economy. To begin with, the interplan annual growth rate of oil and gas exports is 2.5 percent compared to 1.0 percent achieved in the Base Run [13]. Hence, accumulated oil revenues exceed by 27.3 percent the Base figures which, in turn, enable the system to reduce the

[12] This and the following figures are based on the Table about Macroeconomic Results of the Appendix.

Figure 7.14

Oil Exports Under Different Domestic Energy Demand Scenarios.



foreign exchange constraint by making more principal payments. Overall, foreign debt repayments are 55.2 bp in excess of Base figures, although 11.6 bp less than in the case of a jump in the price of oil seen in section 7.1.

Moreover, higher oil revenues also moderate to a certain extent the growth needed in the production of tradeable goods, particularly in both manufacturing industries: the average annual rate of growth of capital and the rest of manufacturing goods is 5.8 and 3.8 percent respectively, compared to 6.0 and 4.0 percent obtained in the Reference Case. This is reflected in the overall ratio of production of tradeable to NT goods, which is lowered from the Base and high energy domestic consumption cases as seen in Figure 7.12.

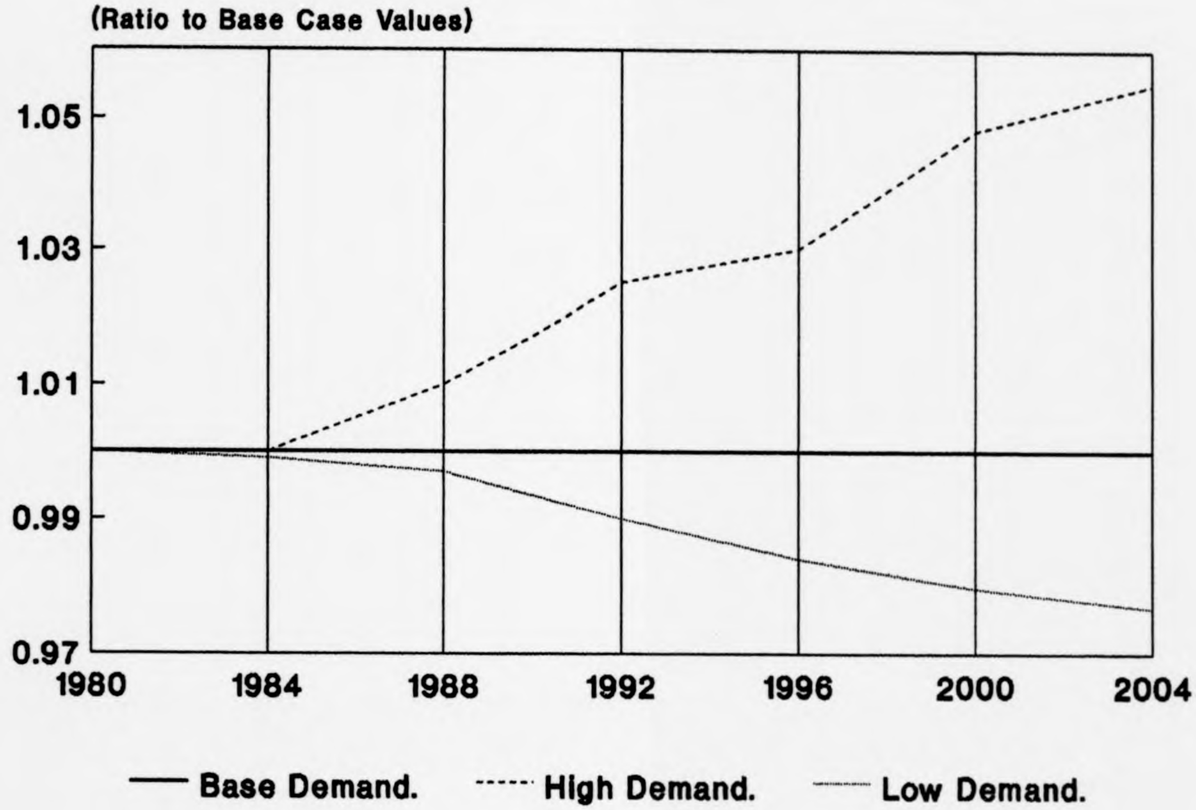
Figure 7.15 basically presents the same story: it shows the magnitude of the reallocation of capital towards the traded sector with changing domestic energy consumption. At the end of the planning period, total capital stock in this sector is about 3 percent lower with low energy domestic consumption than in the Base Run, while in the opposite case KT is 6 percent higher towards the end of the plan period.

7.5 Sensitivity to Alternative Weights on Terminal Assets.

As has been mentioned frequently, an optimizing model crucially depends on the choice of the objective function, because all activity levels are calculated according to the specified Maximand. The objective function used so far in this study consists in maximizing the present value of the

Figure 7.15

Stock of Capital in the Traded Sector Under Different Energy Demand Scenarios.



aggregate consumption stream along the model's plan horizon. In addition, given that this horizon is finite, it is necessary to impose terminal conditions on the assets of future generations (to avoid bang-bang solutions), which are also included in the Maximand. Despite that this objective function seems to be a plausible approximation to Social Welfare and though it has proved to be successful in the sense that the overall results of the model are satisfactory, including the behaviour of the different intertemporal shadow prices, it still is necessary to test the sensitivity of the optimal growth path to changes in the Maximand.

The experiment carried out in this respect consists in dropping the terminal conditions out of the objective function and adding them as an inequality constraint of the system. That is, what is maximized is the present value of aggregate consumption throughout the model's horizon, without the addition of the three sets of assets that constitute Mexico's wealth (i.e. capital stocks, oil and gas underground, and foreign assets). The terminal conditions on these assets are now specified as a constraint whose value has to be greater or equal to the observed value of the Base Run. The remaining equations of the model as well as the data base are equal to the Reference Case.

As theory tells us to expect, the real and dual results using this specification are identical to the Base scenario, which shows that including the terminal conditions either as part of the objective function or as a constraint that has to be satisfied gives the same results provided that the rest of the model and data base do not differ.

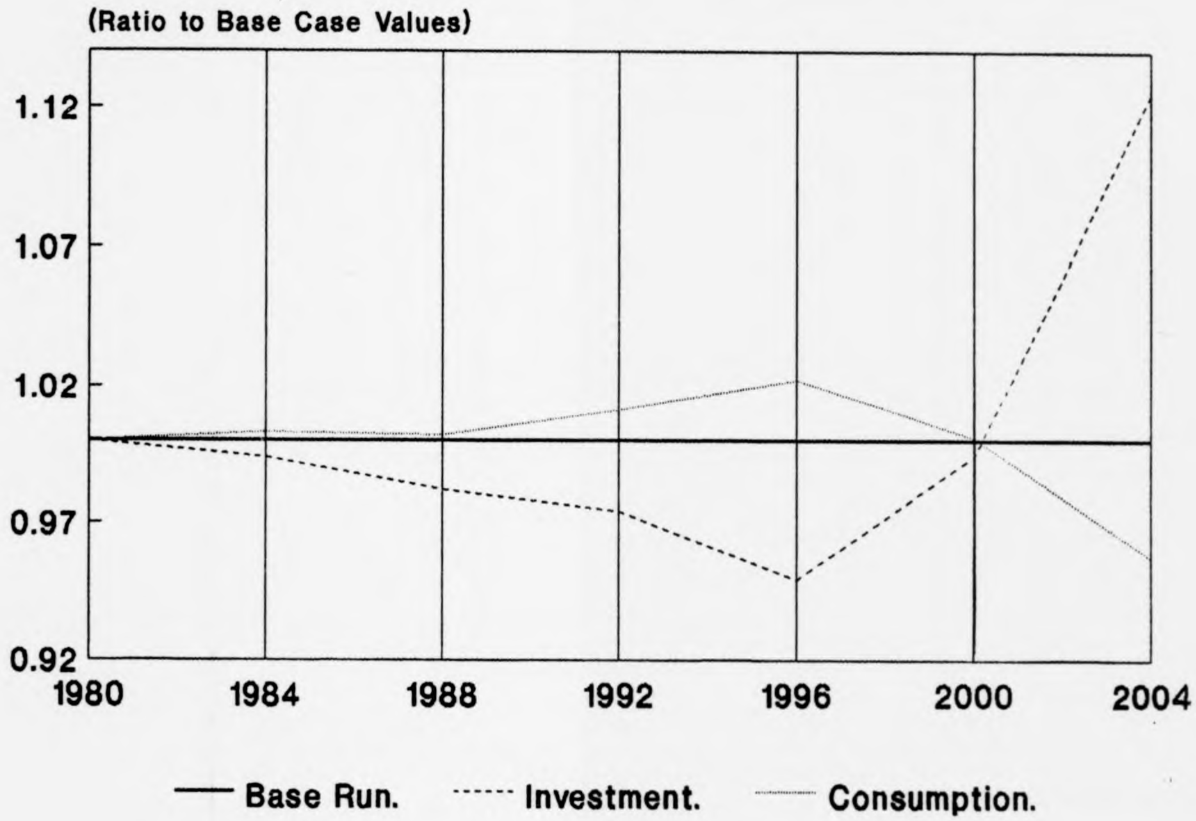
However, an advantage of including the value of terminal assets as a constraint is that it allows us to explore the sensitivity of the results to changes in the value of the inequality. For example, the results to be reported next assume that the value of the three assets has to be greater or equal to a figure which is 20 percent above the Base level. In other words, the model gives now more weight to the wealth of future generations.

By doing so, the model chooses to increase the interplan annual growth rate of investment from 1.3 percent in the Reference Case to 1.8 percent. Thus, in Figure 7.16 investment is seen 12.5 percent above the corresponding Base level at the end of the plan period, which is when the increase in the value of the assets comes into play. Yet, during 1980-2000 investment is slightly below the already depressed Base figures.

Overall then, investment expenditures are below the growth of the economy, so that with a labour force expanding at more than 3.5 percent, this lack of investment has serious longterm implications because it builds up bottlenecks which stand in the way of the resumption of minimal rates of growth. In effect, as can be seen in the Macroeconomic Results Table of the appendix, GDP still grows at 2.7 percent throughout which implies a growing acute imbalance between growth and high-employment growth requirements.

Figure 7 .16

Consumption and Investment Under Different Weights on Terminal Assets.



The more weight terminal assets acquire, come, to some extent, at the expense of consumption which falls by 4.3 percent towards the end (see again Figure 7.16). By contrast, in comparison with the Base scenario, the model decides to roll over a lower amount of foreign debt after the planning period, leaving, therefore, a reduced debt burden to be bequeathed to future generations: 1197.5 bp instead of 1337.2 bp of the Base Case [14].

In order to find resources for debt payments, oil and gas reserves are depleted to the maximum allowed levels. In short then, by raising the value of terminal assets the model chooses to increase the share of real capital assets (in the last period), but mainly it augments the proportion of foreign assets in total wealth, while decumulation of oil and gas reserves is not altered in relation to the Reference Case.

The reduction in the foreign exchange constraint is also captured in the shadow prices presented in the appendix, where the annual rate of discounting of foreign exchange between each period is higher than the corresponding Base figures. Accordingly, most goods and services become more expensive relative to the cost of foreign exchange (as ratio to Base values). Yet, one unit of foreign exchange is still worth more than one unit of any other domestic good excluding, as before, traded goods (except mining), and, to lower extent, electricity.

[14] Higher principal payments than in the Base Case mean that total net outward resource transfers increase on average from 4.8 to 5.2 percent.

7.6 Sensitivity to Alternative External Debt Conditions.

In all the experiments carried out above, including the Base scenario, the level of accumulated foreign debt contracted by Mexico at the end of the year 1984 has been considered as excessive in so far as the various model solutions have chosen to reduce it [15]. An obvious question then is: what would have happen if Mexico had not incurred in such indebted levels, or equivalently, if some of the capital flight had returned to the country. Table 7.13 shows a considerable divergence between capital flight estimates, but it reached at least $21.9 billion in 1980-1984.

Table 7.13
Estimates of Capital Flight
in Mexico, 1980-1984.

	(Billion $US)	(1980 bp)
Morgan Guaranty	40.2	934.9
Cuddington	30.3	704.7
Zedillo	21.9	509.3

Source: Lessard and Williamson (1987).

This experiment assumes a significantly lower foreign borrowing level in 1980-1984: 617.0 bp instead of 1234.1 bp, so that total accumulated external debt is 1629.1 bp and not the observed 2246.2 bp. In other words, it is assumed that 617.1 bp of capital flight had returned to the country by the end of the year 1984. Again, the remaining assumptions

[15] Recall that the 1984 debt figure corresponds to the observed value, but from that year on the model decides how much to borrow or repay, comparing the shadow value of foreign exchange and the marginal revenues on domestic assets.

are identical to the Base Run, including the objective function.

Table 7.14 presents the sensitivity of a reduction in the initial external debt level on the behaviour of the main macroeconomic aggregates.

Table 7.14
Impact of a Reduction in the 1984 External Debt Level on Main Macroeconomic Aggregates, 1980-2004 [1].
(Percentages)

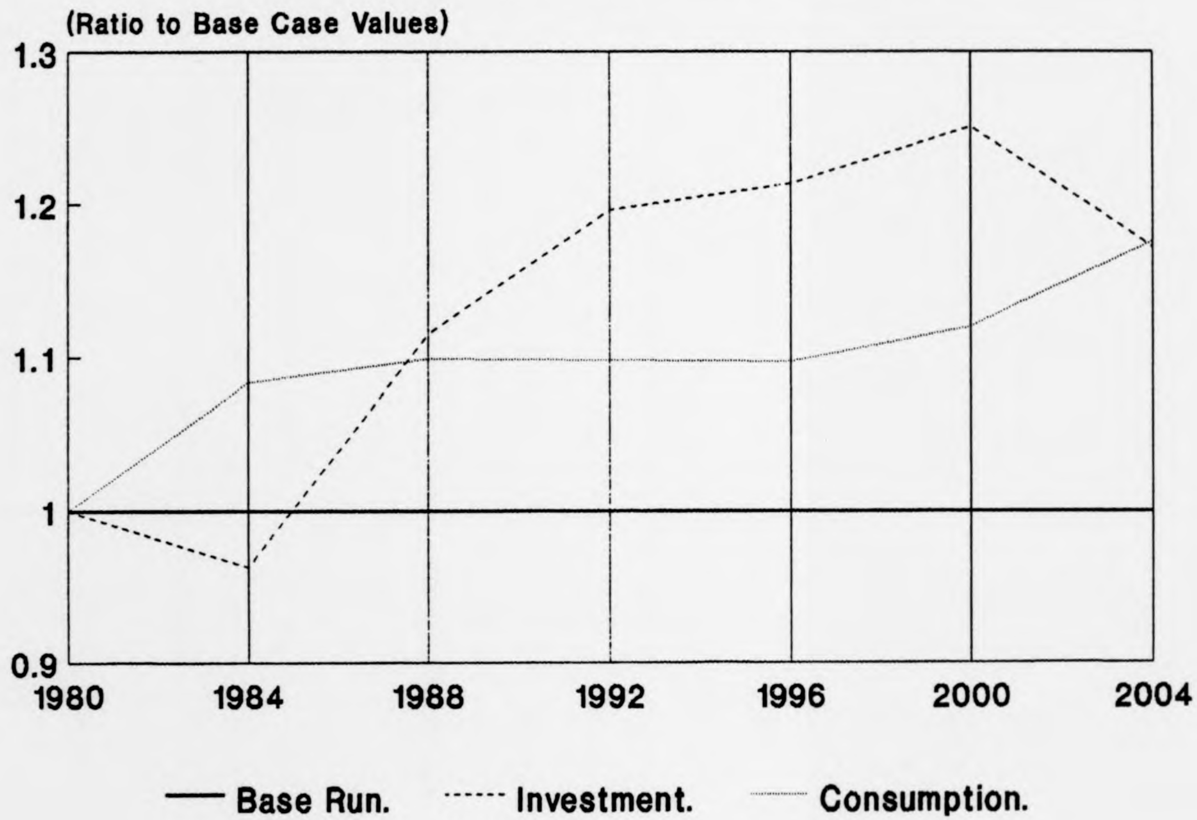
Period	GDP 2246.2	GDP 1629.1	Consumption 2246.2	Consumption 1629.1	Investment 2246.2	Investment 1629.1
1980-1984	1.4	3.2	4.0	6.1	3.7	2.7
1984-1988	2.4	3.5	3.1	3.4	-4.1	-0.5
1988-1992	4.0	4.2	3.6	3.6	0.5	2.3
1992-1996	4.7	4.1	3.5	3.4	3.7	4.0
1996-2000	2.3	3.0	2.0	2.5	0.6	1.4
2000-2004	1.7	1.9	1.5	2.7	3.5	1.9
1980-2004	2.7	3.3	2.9	3.6	1.3	1.9

[1] Average annual growth rates.

It is not surprising that when the foreign exchange constraint is loosened from the beginning of the model's horizon, the performance of the economy improves considerably. GDP growth goes from 2.7 percent on average in the Base Run to 3.3 percent, and in some periods the difference is more than a full percentage point. Things are much brighter for our welfare indicator, as consumption growth is higher in most time periods, and towards the end it is more than 17 percent above Base values (see Figure 7.17). In per capita terms, consumption also increases significantly in comparison to the Reference scenario as a result of the reduction in the proportion of total net

Figure 7.17

Consumption and Investment Under Different Initial External Debt Levels.



transfer of resources (TNTR) to GDP as described in Table 7.15.

Table 7.15
TNTR and Consumption Under Different
Initial External Debt Levels, 1980-2004.

Period	TNTR (% GDP) Base	TNTR (% GDP) Alt.	Per Capita Cons'n Base	Per Capita Cons'n Alt.
1980-1984	22.3	8.6	44.6	48.3
1984-1988	-8.1	-5.6	46.4	50.9
1988-1992	-5.4	-3.1	45.8	54.2
1992-1996	-4.1	-2.5	48.6	57.4
1996-2000	-3.3	-2.0	49.0	58.9
2000-2004	-3.0	-1.6	48.6	62.1
1984-2004	-4.8	-3.0	47.7	56.7

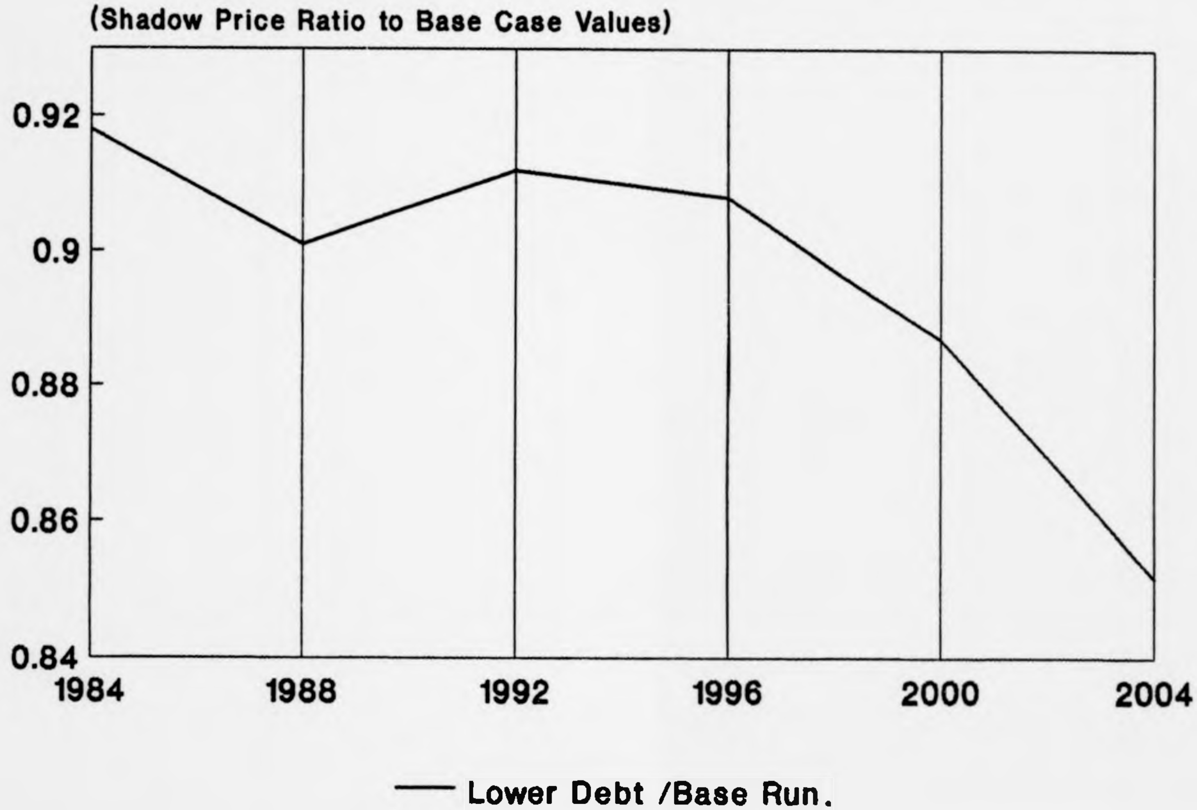
The reduction in the debt burden constraint also allows the economy to increase the proportion of current income that is allocated to investment. Figure 7.17 shows that total investment expenditures as a proportion of Base values is in some periods above 20 percent.

To make all this possible, a major reduction in foreign debt payments is called for, since oil export revenues are constrained by the upper bounds on production. Total accumulated foreign debt payments amount to 584.4 bp (35.8 percent less than in the Reference Case), which combined with lower debt service payments are equivalent to 3.0 percent of GDP on average, well below the 4.8 percent obtained in the Base Scenario. The reduction in the foreign exchange constraint is also reflected in a lower shadow price compared to the Base Run, as Figure 7.18 makes clear.

The second set of experiments regarding debt parameters refers to changes in the real interest on foreign debt.

Figure 7.18

Foreign Exchange Constraint Under Different Initial External Debt Levels.



Before explaining the experiment, it is convenient to explain the importance of this parameter for the Mexican economy. Solis and Zedillo (1986) have offered a decomposition of the increase in debt in 1979-81. They conclude that about one third of the debt increase can be attributed to external shocks, most of which was due to the increase in world interest rates.

Table 7.16
Source of Increase in the External Debt: 1979-81
(Percent of Total Debt Increase)

	1979	1980	1981
External Shocks	33.1	28.7	16.2
Interest Rate	25.9	27.2	17.8
Internal Shocks	66.9	71.3	83.8
Capital Flows	49.7	44.3	55.7

Source: Solis and Zedillo (1986, Table 10-6).

Between 1978 and 1981 the 3 month Libor Rate increased from 8.8 to 16.8. By itself, this increase in interest rates, if financed by new bonds, would have raised the debt by 8 percent per year. Moreover, in the last few years Mexico's external environment has deteriorated due to the fall in oil prices and the fact that world interest rates have increased sharply mainly as a result of the US shift to tight monetary policy. Despite all this, Mexico is paying all the interest that is owed abroad. The decline in investment and the depressed economic conditions make this possible.

Similarly, one of the main results of the Base Run is that the burden of debt service is a source of much too low investment. The return on investment is lower than the real interest rate on foreign debt (8 percent), and given that interest payments represent more than a third of total exports in 1984, the model finds it more profitable to reduce the level of accumulated external debt than to invest in domestic assets. As indicated then, the amount of total net outward transfers also calls for oil and gas reserves to be extracted at the maximum levels throughout so as to get the foreign exchange needed to meet the external commitments.

Nowadays, Mexican authorities are trying to renegotiate a high proportion of the debt contracted with the commercial banks and, among other options, Mexico is seeking a reduction in interest rates [16]. This raises the question: what would be the effect in the optimal solution of the model of a reduction in the real interest rate? To make this scenario more favourable to the Mexican economy, a reduction in the interest rate on foreign debt from 8 to 5 percent, is combined with an increase in the price of oil identical to the optimistic scenario reported in section 7.1

---

[16] Banks can choose from three options (Financial Times, August 4 1989):
(a). Swap their old loans for new 30-year bonds at a discount to face value of 35 percent. These discount bonds will carry an interest margin of 13/16 percentage point over money market rates.
(b). Swap their old loans for new 30-year bonds with the same face value. These par bonds would carry a below-market fixed interest rate of 6.25 percent.
(c). Provide new loans over a four-year period equivalent to a total 25 percent of their current medium and long-term exposure. The new loans would be repayable in 15 years, with seven years before any principal is repaid, and carry an interest margin of 13/16 point.
The bonds under the the first two options are "enhanced" by $7 billion in resources, including funds from the World Bank, IMF and the Japanese Ex-Im Bank.

(oil prices jump to $30 per barrel in the year 2004 but otherwise they increase by 2 percent in real terms).

As can be seen in Table 7.17, the model decides to reduce the rate of oil extraction towards the end of the plan horizon. Specifically, in the last two periods of the model optimal oil production is set below the maximum rates because now, with the reduction in the burden of debt service and higher expected future oil prices, it is worth keeping oil and gas in the ground. This is translated into a slight increase in the ratio of reserves to extraction from 27 to 30 years at the end of the planning period.

Table 7.17
Optimal and Maximum Oil and Gas Extraction and Reserve Levels, 1984-2004.
(Millions of Barrels)

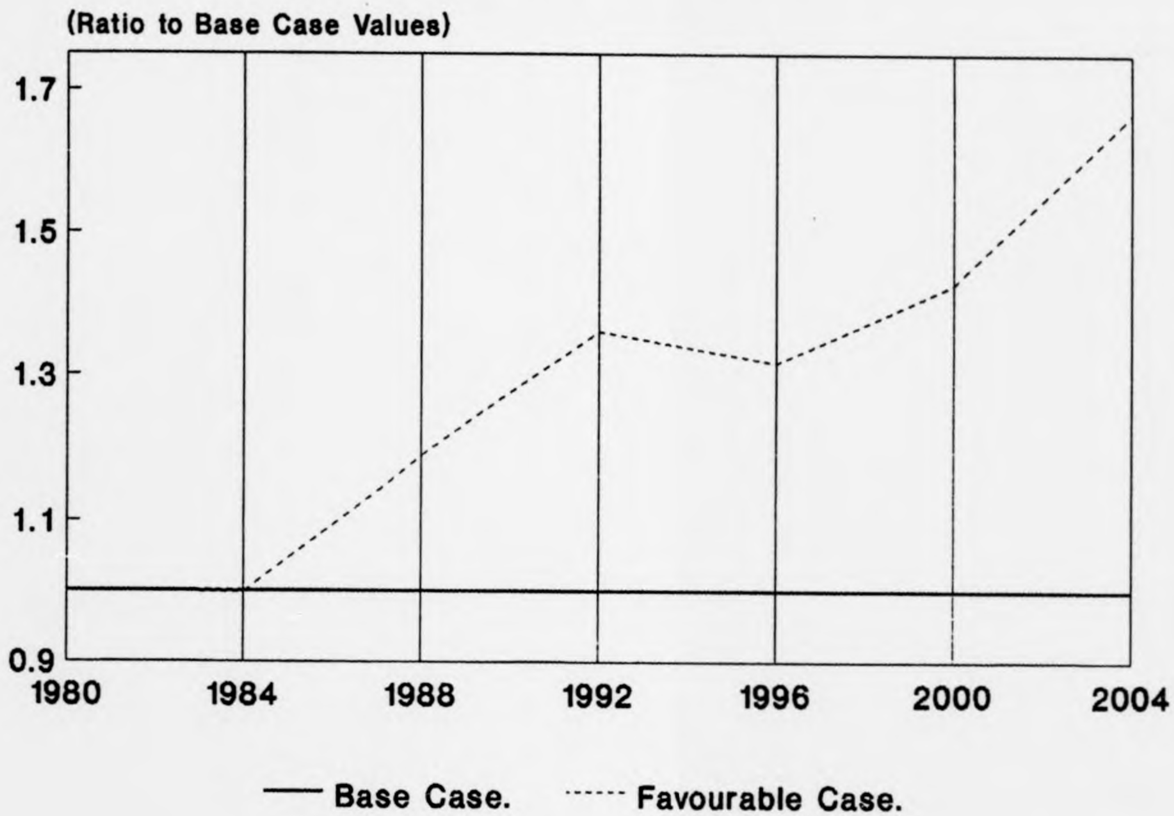
	Extraction Levels:			
Year	Optimal (1)	Maximum (2)	Reserves (3)	Years (3/1)
1984	1393.0	1393.0	71750	51.5
1988	1256.2	1256.2	71750	57.1
1992	1396.0	1396.0	66725	47.8
1996	1551.5	1551.5	61141	39.4
2000	1643.4	1675.6	55455	33.5
2004	1621.5	1776.1	48936	30.2

Moreover, the much improved external environment also calls for a reduction in principal payments from 909.0 bp in the Base Run to 691.9 bp [17], thus freeing resources for much needed investment expenditures. Figure 7.19 shows that investment is consistently higher than in the Base Case,

[17] The reduction in principal and interest payments means that net transfer of resources from Mexico to its foreign creditors falls to 3.2 percent on average in 1984-2004, and by the end of the year 2004 it represents only 2.2 percent, which as shall be explain later, it coincides with a big jump in investment expenditures.

Figure 7 .19

Investment Under Different External Conditions.



particularly at the end of the horizon, when it is almost 70 percent above (see also the Table about Macroeconomic Results shown in the appendix).

Table 7.18 describes the sensitivity of the main macroeconomic aggregates to the two alternative international trade and financial conditions. It shows that some luck in external conditions would imply a shift of resources towards investment, which would then be translated into an expansion in capacity, and thus enabling the economy to increase its overall growth rate to 3.3 percent. This means that GDP growth is 13.7 percent above Base figures towards the end of the model's horizon (see Figure 7.20). Actually, in terms of economic growth this scenario performs better than the case where the upper bound on oil extraction was relaxed to the maximum (see section 7.2), with the additional advantage that decumulation of oil reserves is greatly diminished: there would be oil reserves for more than 30 years instead of only 13 when oil depletion is increased.

Table 7.18
Annual Growth Rates of the Main Macroeconomic Aggregates
Under Different International Conditions, 1980-2004.
(Percentages)

	GDP		Consumption		Investment	
Period	Base	Alt.	Base	Alt.	Base	Alt.
1980-1984	1.4	1.4	4.0	4.0	3.7	3.6
1984-1988	2.4	4.1	3.1	3.1	-4.1	0.2
1988-1992	4.0	4.3	3.6	3.9	0.5	4.0
1992-1996	4.7	4.4	3.5	3.5	3.7	2.8
1996-2000	2.3	2.6	2.0	2.0	0.6	2.6
2000-2004	1.7	2.9	1.5	1.5	3.5	8.3
1980-2004	2.7	3.3	2.9	3.0	1.3	3.5

particularly at the end of the horizon, when it is almost 70 percent above (see also the Table about Macroeconomic Results shown in the appendix).

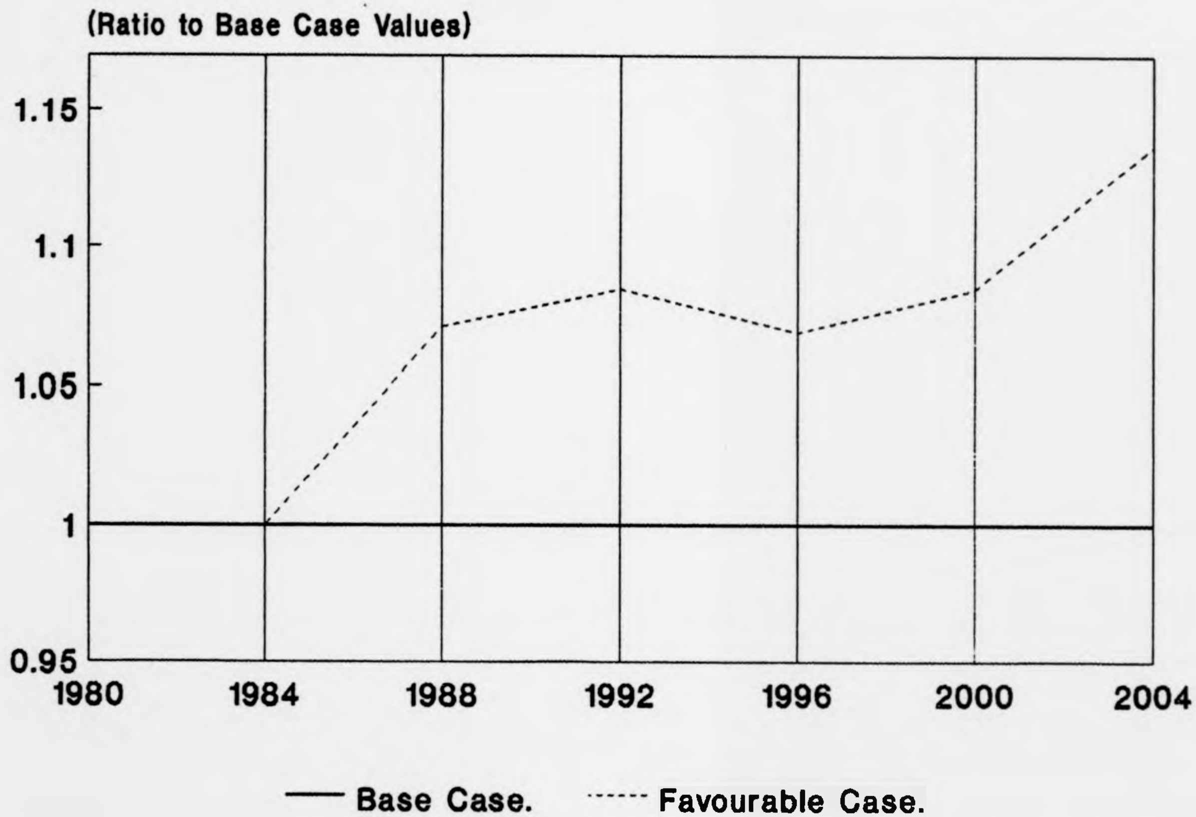
Table 7.18 describes the sensitivity of the main macroeconomic aggregates to the two alternative international trade and financial conditions. It shows that some luck in external conditions would imply a shift of resources towards investment, which would then be translated into an expansion in capacity, and thus enabling the economy to increase its overall growth rate to 3.3 percent. This means that GDP growth is 13.7 percent above Base figures towards the end of the model's horizon (see Figure 7.20). Actually, in terms of economic growth this scenario performs better than the case where the upper bound on oil extraction was relaxed to the maximum (see section 7.2), with the additional advantage that decumulation of oil reserves is greatly diminished: there would be oil reserves for more than 30 years instead of only 13 when oil depletion is increased.

Table 7.18
Annual Growth Rates of the Main Macroeconomic Aggregates Under Different International Conditions, 1980-2004.
(Percentages)

	GDP		Consumption		Investment	
Period	Base	Alt.	Base	Alt.	Base	Alt.
1980-1984	1.4	1.4	4.0	4.0	3.7	3.6
1984-1988	2.4	4.1	3.1	3.1	-4.1	0.2
1988-1992	4.0	4.3	3.6	3.9	0.5	4.0
1992-1996	4.7	4.4	3.5	3.5	3.7	2.8
1996-2000	2.3	2.6	2.0	2.0	0.6	2.6
2000-2004	1.7	2.9	1.5	1.5	3.5	8.3
1980-2004	2.7	3.3	2.9	3.0	1.3	3.5

Figure 7.20

GDP Under Different External Conditions.



This Table also indicates that consumption increases slightly relative to the Base Run, but it is clear that the model chooses to allocate a higher proportion of the resources freed towards investment rather than consumption. This is because the higher marginal productivity of capital at lower interest rates implies more investment which was not the case, for example, when the initial debt level was lowered. On top of that, an optimal growth strategy will require that overall, investment should grow faster than both consumption and GDP.

As in the Base scenario, a big share of total investment should be directed into export expanding and import-substituting activities given that now oil export revenues are dearer since it is more profitable to keep oil in the ground. In addition, over the next two decades the growth of non-oil merchandise exports will have to be about 12 percent per year and imports will have to grow more slowly than total exports.

In sum, in the presence of a large external debt burden, a more favourable external environment in terms of both a reduction in interest rates and an increase in the expected price of oil, has the effect of loosening the external exchange constraint with the consequent advantages for the domestic economy:

- It frees resources that can be devoted to longterm investment with the subsequent expansion in capacity and growth.

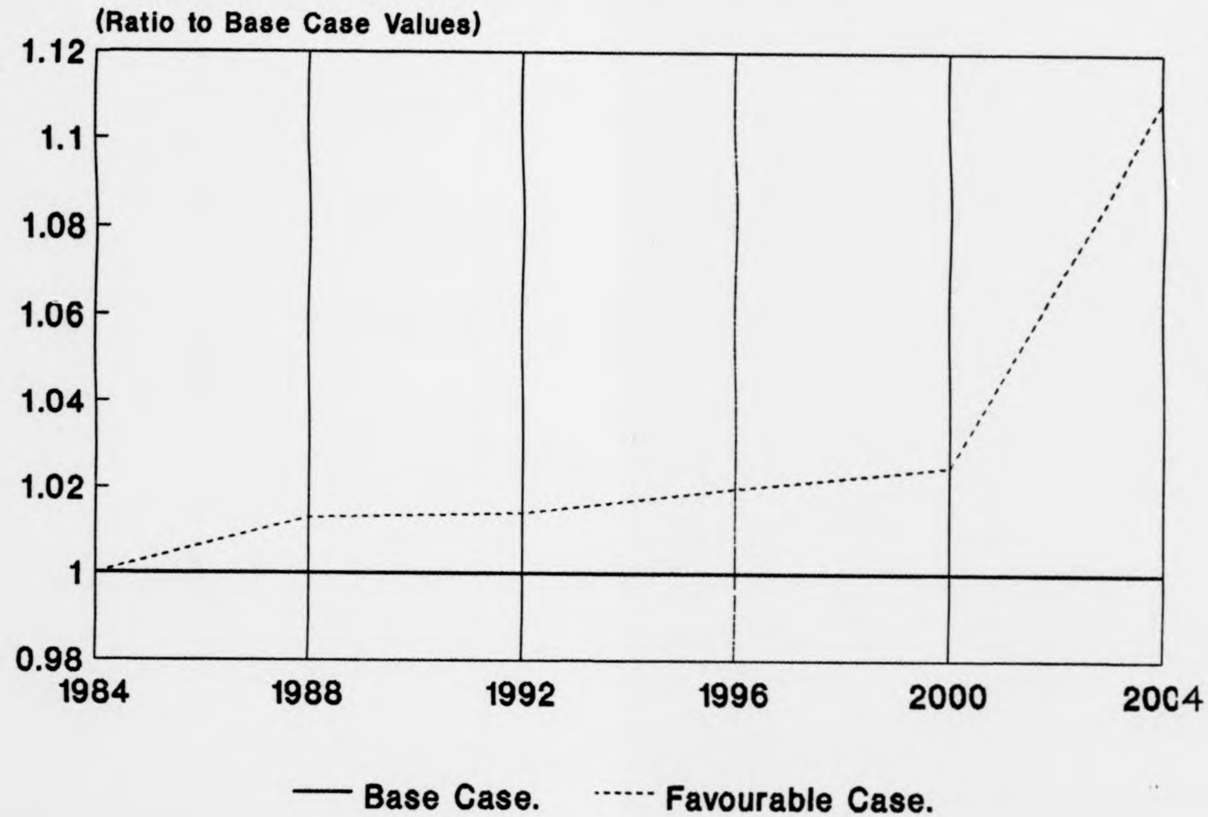
- There is a reduction in oil depletion levels so that future generations can exploit this when oil and gas become more profitable.

- The reduction in foreign exchange constraint allows some real appreciation of the external exchange rate (price of domestic goods in terms of imports) in relation to the Base Case (see Figure 7.21), which can provide a breathing space for stabilization of inflation. That is, price stability could be established without recession and thus sustains job creation.

The main purpose of the above experiments has been to gain some insights about some of the important energy-economy interactions faced by the Mexican economy over the next two decades. Overall, the various solutions can be explained by applying accepted theory. Although these experiments represent only a small sample of several possibilities, it is hoped that they have illustrated the character of the results of the model.

Figure 7.21

Real External Exchange Rate Under Different External Conditions.



Price of Domestic Goods / Imports.

APPENDIX.

Macroeconomic Results, Gross Output Levels, and Shadow Prices of the Alternative Scenarios.

7.1 Sensitivity to Alternative Elasticities of Substitution.

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3138.1	3455.2	3843.0	4330.9	4631.7	4981.7	2.3
Investment*	1207.6	1259.7	1058.6	1070.2	1178.6	1201.2	1338.2	0.4
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	288.7	227.8	243.2	254.2	261.1	303.9	1.2
% Tot.Exp.	54.4	51.4	25.8	20.7	16.4	15.3	15.9	
Manuf. Exp.	89.2	163.2	537.0	804.8	1154.5	1300.1	1445.1	12.3
% Tot.Exp.	21.4	29.1	60.8	68.4	74.6	76.0	75.6	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	19.5	13.4	10.9	8.9	8.7	8.5	
Total Exports	418.2	561.3	883.2	1176.1	1546.9	1710.4	1910.3	6.5
Total Imports	528.1	1103.9	1233.5	1363.8	1380.2	1348.0	1616.0	4.8
Trade Deficit	90.9	542.6	350.3	187.8	-166.7	-362.4	-294.3	
GDP	4470.1	4339.8	4686.9	5290.3	6286.7	6854.7	7326.3	2.1
Foreign Bor.	-	1234.1	-276.1	-110.0	- 95.3	-74.3	-47.4	
Acc.For.Debt	1012.1	2246.2	1970.1	1860.1	1764.8	1690.5	1643.1	
% GDP	22.6	51.8	42.0	35.2	28.1	24.7	22.4	
Interest Pay.	81.0	179.7	157.6	148.8	141.2	135.2	131.4	
% Tot.Exp.	19.4	32.0	17.8	12.7	9.1	7.9	6.9	
% GDP	1.8	4.1	3.4	2.8	2.2	2.0	1.8	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	490.7	513.0	540.9	601.7	683.1	726.2	1.5
Min	97.8	126.4	183.6	225.6	242.7	254.2	285.5	4.6
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	112.0	119.8	166.5	200.4	228.6	262.7	4.3
Pet	19.7	20.3	23.7	29.2	35.2	36.6	34.7	2.4
MCa	647.0	981.7	1440.3	2230.2	2485.8	2671.5	2888.4	6.4
MRe	1649.4	1674.3	1738.4	2203.6	3040.6	3754.9	3992.1	3.8
Con	608.3	648.5	575.0	596.3	617.1	648.9	698.9	0.6
Ele	78.9	144.4	188.5	205.6	219.1	228.8	236.5	4.7
Tra	404.8	514.5	520.1	675.7	923.9	1007.5	1021.3	3.9
Com	1261.9	1586.7	2445.2	2181.8	2435.1	2490.9	2489.3	2.9
Ser	1249.6	1378.8	2050.6	1875.8	2087.4	2188.1	2146.4	2.3
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.23	1.30	1.31	1.30	1.51	1.06	-0.7
Mining	0.48	0.41	0.54	0.43	0.46	0.33	-1.9
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.82	0.51	0.59	0.60	0.80	0.66	-1.1
Petrochem	0.77	0.70	0.76	0.81	1.11	0.42	-3.0
M Capital	0.98	0.83	0.87	0.91	0.94	0.93	-0.3
M Rest	1.04	0.99	0.66	1.03	1.05	1.08	0.2
Construc.	0.67	0.74	0.66	0.64	0.52	0.48	-1.7
Elect.	1.45	0.98	1.13	1.28	1.40	1.42	-0.1
Transp.	0.62	0.68	0.59	0.53	0.89	0.39	-2.3
Commerce	0.98	0.45	0.70	0.75	0.89	0.50	-3.3
Services	0.96	0.65	0.82	0.86	0.94	0.70	-2.3
Governm't	1.25	1.18	1.18	1.15	1.15	0.90	-1.6
Agg. Cons.	0.989	0.897	0.727	0.880	0.821	0.768	-1.3
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.862	0.473	0.261	0.148	0.112	
% FERP	-3.6	-13.9	-13.8	-13.2	-6.7		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

7.2 Sensitivity to Alternative Oil Price Expectations.

1) <u>Pessimistic Pattern</u>:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3393.2	3826.0	4406.4	5008.4	5422.6	5671.7	2.8
Investment	1207.6	1389.0	1175.1	1200.8	1381.1	1399.9	1601.8	1.2
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.7	185.2	201.0	223.0	233.9	233.2	0.1
% Tot.Exp.	54.4	48.5	22.1	18.1	15.2	14.5	13.0	
Manuf. Exp.	89.2	163.8	535.5	780.1	1102.7	1230.0	1398.2	12.2
% Tot.Exp.	21.4	30.9	63.8	70.3	75.3	76.3	78.0	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	14.1	11.6	9.5	9.2	9.0	
Total Exports	418.2	530.9	839.1	1109.2	1463.9	1613.1	1792.7	6.3
Total Imports	528.1	1070.3	1186.4	1222.6	1216.9	1163.9	1420.1	4.2
Trade Deficit	90.9	539.4	347.3	113.4	-247.0	-449.2	-372.6	
GDP	4470.1	4727.4	5177.2	6059.1	7247.0	7931.1	8358.2	2.6
Foreign Bor.	-	1234.1	-261.4	-181.6	-167.2	-147.9	-150.3	
Acc.For.Debt	1012.1	2246.2	1984.8	1803.2	1636.0	1488.1	1337.8	
% GDP	22.6	47.5	38.3	29.8	22.6	18.8	16.0	
Interest Pay.	81.0	179.7	158.8	144.3	130.9	119.0	107.0	
% Tot.Exp.	19.4	33.8	18.9	13.0	8.9	7.4	6.0	
% GDP	1.8	3.8	3.1	2.4	1.8	1.5	1.3	

* Exogenous.
1 Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	654.8	684.0	692.0	717.2	732.1	734.0	1.5
Min	97.8	121.0	186.3	208.2	224.6	239.4	262.8	4.2
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	118.1	157.0	224.8	270.5	310.4	374.5	5.9
Pet	19.7	28.6	31.2	34.7	38.4	38.6	40.9	3.1
MCa	647.0	953.2	1422.5	2062.2	2298.1	2450.7	2751.1	6.2
MRe	1649.4	1994.3	2315.9	2626.1	3249.3	3975.8	4345.5	4.1
Con	608.3	691.3	613.8	626.2	646.9	656.7	700.7	0.6
Ele	78.9	169.4	214.0	237.2	259.6	270.8	281.5	5.4
Tra	404.8	578.6	707.7	792.3	904.0	954.0	979.4	3.8
Com	1261.9	1929.7	2188.5	2489.1	2567.7	2659.6	2674.8	3.2
Ser	1249.6	1639.7	1903.7	2222.8	2312.2	2414.5	2400.8	2.8
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.09	1.16	1.25	1.26	1.26	0.4
Mining	0.50	0.40	0.42	0.42	0.43	0.46	-0.4
Oil	0.92	0.54	0.59	0.63	0.68	0.35	-1.5
Refining	0.62	0.47	0.49	0.50	0.55	0.46	-1.5
Petrochem	0.59	0.44	0.47	0.47	0.50	0.45	-1.3
M Capital	0.96	0.86	0.86	0.88	0.90	0.98	0.1
M Rest	1.02	0.90	0.93	0.96	1.00	1.02	0.0
Construc.	0.91	0.72	0.56	0.60	0.63	0.66	-1.6
Elect.	1.14	0.93	0.91	0.90	0.84	0.77	-1.9
ransp.	0.67	0.55	0.59	0.57	0.55	0.50	-1.5
Commerce	0.82	0.79	0.68	0.64	0.59	0.49	-2.5
Services	0.86	0.79	0.76	0.69	0.62	0.58	-2.0
Governm't	0.77	0.67	0.67	0.65	0.65	0.57	-1.5
Agg. Cons.	0.919	0.823	0.814	0.807	0.797	0.733	-1.1
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.770	0.431	0.242	0.144	0.111	
% FERP		-6.3	-13.5	-13.4	-12.2	-6.3	

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

2) Optimistic Pattern:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3404.7	3843.1	4419.8	5110.4	5521.1	5818.6	2.9
Investment*	1207.6	1394.4	1182.4	1213.5	1417.3	1455.1	1673.9	1.4
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.7	187.6	203.9	225.8	236.4	411.3	2.5
% Tot.Exp.	54.4	48.6	22.4	18.5	15.6	14.8	21.3	
Manuf. Exp.	89.2	163.7	533.0	772.6	1085.9	1209.6	1360.0	11.8
% Tot.Exp.	21.4	30.8	63.5	70.0	74.9	75.8	70.4	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	14.1	11.6	9.5	9.4	8.3	
Total Exports	418.2	530.7	839.0	1104.5	1449.9	1595.2	1932.6	6.6
Total Imports	528.1	1083.6	1190.6	1218.4	1212.3	1162.4	1397.9	4.1
Trade Deficit	90.9	552.9	351.6	113.9	-237.6	-432.8	-534.7	
GDP	4470.1	4730.9	5197.3	6084.7	7375.8	8068.4	8739.3	2.8
Foreign Bor.	-	1234.1	-262.3	-181.9	-167.8	-150.0	-214.4	
Acc.For.Debt	1012.1	2246.2	1983.9	1802.0	1634.2	1484.2	1269.8	
% GDP	22.6	47.5	38.2	29.6	22.2	18.4	14.5	
Interest Pay.	81.0	179.7	158.7	144.2	130.7	118.7	101.6	
% Tot.Exp.	19.4	33.9	18.9	13.1	9.0	7.4	5.3	
% GDP	1.8	3.8	3.1	2.4	1.8	1.5	1.2	

* Exogenous.
1 Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	655.4	685.3	692.5	718.6	736.3	748.5	1.6
Min	97.8	120.7	185.8	207.4	223.9	238.2	256.4	4.1
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	118.3	156.6	224.1	269.8	306.2	322.6	5.2
Pet	19.7	28.6	31.1	34.6	38.3	38.5	40.2	3.0
MCa	647.0	951.6	1419.2	2057.9	2291.4	2454.4	2550.4	5.9
MRe	1649.4	1993.6	2312.2	2623.4	3244.9	3974.3	4089.8	3.8
Con	608.3	692.5	613.2	621.5	634.9	636.7	722.1	0.7
Ele	78.9	169.4	213.8	236.8	258.3	269.0	275.0	5.3
Tra	404.8	578.6	708.1	792.4	904.2	951.0	1024.7	4.0
Com	1261.9	1929.5	2190.6	2491.2	2566.0	2647.3	2707.7	3.2
Ser	1249.6	1639.6	1904.4	2224.0	2311.1	2409.6	2454.3	2.9
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.06	1.13	1.25	1,28	1.40	0.9
Mining	0.50	0.38	0.40	0.41	0.42	0.50	0.0
Oil	0.92	0.54	0.59	0.63	0.68	1.04	0.6
Refining	0.62	0.46	0.49	0.50	0.54	0.65	0.2
Petrochem	0.59	0.44	0.47	0.47	0.50	0.59	0.0
M Capital	0.96	0.82	0.82	0.83	0.85	0.90	-0.3
M Rest	1.02	0.87	0.89	0.92	0.98	1.03	0.0
Construc.	0.91	0.72	0.57	0.60	0.64	0.70	-1.3
Elect.	1.14	0.92	0.93	0.89	0.87	0.90	-1.2
Transp.	0.67	0.56	0.60	0.60	0.57	0.54	-1.1
Commerce	0.82	0.78	0.69	0.65	0.59	0.57	-1.8
Services	0.86	0.80	0.77	0.71	0.64	0.66	-1.3
Governm't	0.77	0.67	0.68	0.66	0.65	0.56	-1.6
Agg. Cons.	0.919	0.822	0.814	0.808	0.801	0.869	-0.3
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.773	0.432	0.242	0.132	0.082	
% FERP	-6.2	-13.5	-13.5	-14.1	-11.2		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

7.3 Sensitivity to Alternative Oil Production Ceilings.

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3413.5	3864.6	4449.0	5118.3	5554.2	5925.9	3.0
Investment*	1207.6	1385.4	1183.9	1218.2	1430.1	1529.0	1759.9	1.6
Government	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.9	341.9	404.7	477.9	540.3	664.7	4.4
% Tot.Exp.	54.4	48.6	35.0	31.8	29.2	29.9	31.0	
Manuf. Exp.	89.2	163.7	516.5	737.9	1022.8	1115.0	1321.5	11.9
% Tot.Exp.	21.4	30.8	52.9	58.1	62.4	61.8	61.5	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	12.1	10.1	8.4	8.3	7.5	
Total Exports	418.2	531.0	976.8	1270.7	1638.9	1804.5	2147.5	6.8
Total Imports	528.1	1083.1	1176.1	1204.0	1198.4	1148.2	1391.2	4.1
Trade Deficit	90.9	552.1	199.3	-66.6	-440.5	-656.3	-756.3	
GDP	4470.1	4731.4	5372.6	6297.2	7599.2	8398.9	9154.2	3.0
Foreign Bor.	-	1234.1	-369.9	-301.2	-253.4	-161.1	-236.0	
Acc.For.Debt	1012.1	2246.2	1876.3	1575.1	1321.7	1160.6	924.6	
% GDP	22.6	47.5	34.9	25.0	17.4	13.8	10.1	
Interest Pay.	81.0	179.7	150.1	126.0	105.7	92.8	74.0	
% Tot.Exp.	19.4	33.8	15.4	9.9	6.4	5.1	3.4	
% GDP	1.8	3.8	2.8	1.9	1.4	1.1	0.8	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	656.9	686.7	694.1	722.0	739.7	753.6	1.6
Min	97.8	120.8	182.1	202.5	217.2	231.0	250.2	4.0
Oil	292.2	391.7	506.1	590.4	674.8	745.1	815.4	4.4
Ref	95.2	118.4	157.5	225.9	273.6	313.5	365.5	5.8
Pet	19.7	28.6	31.2	34.9	38.7	38.9	41.2	3.1
MCa	647.0	946.9	1379.5	1984.0	2188.3	2314.9	2448.8	5.7
MRe	1649.4	1983.1	2247.9	2540.4	3094.9	3756.1	4182.8	4.0
Con	608.3	693.4	615.3	627.8	646.3	653.4	737.2	0.8
Ele	78.9	169.5	213.8	238.0	259.1	269.8	280.1	5.4
Tra	404.8	582.8	712.9	798.1	910.3	959.9	1027.8	4.0
Com	1261.9	1933.2	2192.0	2492.7	2566.3	2657.8	2722.5	3.3
Ser	1249.6	1645.6	1911.0	2231.2	2320.5	2421.9	2463.6	2.9
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.06	1.15	1.26	1.28	1.37	0.8
Mining	0.50	0.38	0.41	0.42	0.43	0.50	0.0
Oil	0.92	0.54	0.60	0.63	0.70	0.76	-0.9
Refining	0.62	0.46	0.50	0.51	0.54	0.53	-0.8
Petrochem	0.59	0.44	0.47	0.47	0.52	0.51	-0.7
M Capital	0.96	0.83	0.83	0.84	0.89	0.98	0.1
M Rest	1.02	0.88	0.91	0.93	1.01	1.07	0.2
Construc.	0.91	0.72	0.58	0.63	0.65	0.70	-1.3
Elect.	1.14	0.92	0.91	0.90	0.88	0.83	-1.6
Transp.	0.67	0.55	0.59	0.58	0.58	0.52	-1.3
Commerce	0.82	0.78	0.69	0.65	0.61	0.57	-1.8
Services	0.86	0.79	0.76	0.72	0.65	0.64	-1.5
Governm't	0.77	0.67	0.68	0.65	0.64	0.56	-1.6
Agg. Cons.	0.919	0.822	0.818	0.814	0.819	0.815	-0.6
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.773	0.430	0.238	0.129	0.081	
% FERP	-6.2	-13.6	-13.7	-14.2	-11.0		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

7.4 Sensitivity to Alternative Utility Function Parameters.

1) Lower Rate of Pure Time Preference:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3258.8	3669.3	4487.5	5230.2	5663.7	6075.2	3.1
Investment*	1207.6	1483.6	1252.3	1291.6	1473.2	1520.0	1724.6	1.5
Government	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	263.7	187.3	193.1	206.2	214.7	275.6	0.8
% Tot.Exp.	54.4	48.4	21.9	17.2	13.9	13.1	14.6	
Manuf. Exp.	89.2	171.5	549.8	803.4	1134.8	1268.9	1450.9	12.3
% Tot.Exp.	21.4	31.5	64.3	71.4	76.7	77.7	76.9	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.1	13.8	11.4	9.4	9.2	8.5	
Total Exports	418.2	544.6	855.5	1124.6	1479.2	1632.8	1887.8	6.5
Total Imports	528.1	1121.8	1291.7	1329.2	1314.7	1260.9	1577.3	4.7
Trade Deficit	90.9	577.2	436.2	204.6	-164.5	-371.9	-310.5	
GDP	4470.1	4589.8	5008.8	6139.8	7478.4	8215.0	8822.4	2.9
Foreign Bor.	-	1234.1	-308.6	-162.1	-141.6	-135.2	-130.2	
Acc.For.Debt	1012.1	2246.2	1937.6	1775.5	1633.9	1498.7	1368.5	
% GDP	22.6	48.9	38.6	28.9	21.8	18.2	15.5	
Interest Pay.	81.0	179.7	155.0	142.0	130.7	119.9	109.5	
% Tot.Exp.	19.4	33.0	18.1	12.6	8.8	7.3	5.8	
% GDP	1.8	3.9	3.1	2.3	1.7	1.5	1.2	

* Exogenous.
1 Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	635.4	671.2	712.8	725.8	749.1	758.4	1.7
Min	97.8	117.7	174.1	211.7	240.3	264.6	282.0	4.5
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	106.8	140.4	234.4	293.5	329.6	385.6	6.0
Pet	19.7	28.1	31.2	36.9	39.1	42.5	43.7	3.4
MCa	647.0	939.2	1294.2	2096.9	2366.8	2610.3	2837.2	6.4
MRe	1649.4	1886.3	2201.6	2641.6	3615.7	4428.1	4742.0	4.5
Con	608.3	671.3	566.6	640.1	715.9	723.8	801.8	1.2
Ele	78.9	158.7	201.4	252.7	275.8	288.1	297.0	3.7
Tra	404.8	566.2	692.6	842.4	960.9	1013.3	1077.9	4.2
Com	1261.9	1791.4	2032.8	2698.9	2781.8	2878.7	2911.0	3.5
Ser	1249.6	1599.1	1856.9	2246.1	2336.0	2438.1	2550.6	3.0
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.07	1.13	1.20	1.17	1.17	0.0
Mining	0.50	0.39	0.45	0.40	0.38	0.43	-0.8
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.62	0.46	0.50	0.51	0.53	0.53	-0.8
Petrochem	0.59	0.44	0.49	0.48	0.50	0.50	-0.8
M Capital	0.96	0.84	0.83	0.86	0.86	0.92	-0.2
M Rest	1.02	0.90	0.91	0.91	0.92	1.00	-0.1
Construc.	0.91	0.77	0.66	0.72	0.68	0.64	-1.7
Elect.	1.14	0.95	0.92	0.88	0.85	0.79	-1.8
Transp.	0.67	0.55	0.59	0.58	0.54	0.48	-1.7
Commerce	0.82	0.78	0.67	0.65	0.59	0.51	-2.3
Services	0.86	0.79	0.77	0.72	0.62	0.59	-1.9
Governm't	0.77	0.69	0.69	0.66	0.64	0.55	-1.7
Agg. Cons.	0.919	0.839	0.818	0.804	0.779	0.759	
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.759	0.432	0.260	0.157	0.119	
% FERP	-6.7	-13.1	-11.9	-11.8	-6.7		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

2a) High Domestic Energy Demand Scenario:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3413.0	3836.9	4405.5	4785.3	5308.9	5563.4	2.7
Investment	1207.6	1373.5	1180.8	1192.5	1370.9	1380.5	1584.5	1.1
Government	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	230.6	151.8	155.3	163.8	158.1	185.4	-0.9
% Tot.Exp.	54.4	45.3	18.7	14.5	11.5	10.1	10.6	
Manuf. Exp.	89.2	168.6	541.2	788.2	1117.1	1254.9	1402.6	12.2
% Tot.Exp.	21.4	33.1	66.7	73.6	78.7	80.3	80.2	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	21.5	14.6	11.9	9.7	9.6	9.2	
Total Exports	418.2	508.6	811.4	1071.6	1419.1	1562.2	1749.3	6.1
Total Imports	528.1	1110.0	1219.4	1249.3	1244.8	1198.0	1426.6	4.3
Trade Deficit	90.9	601.4	408.0	177.7	-174.3	-364.2	-322.7	
GDP	4470.1	4669.7	5133.1	5985.6	7141.0	7719.0	8182.7	2.6
Foreign Bor.	-	1234.1	-250.4	-195.3	-165.3	-144.0	-141.8	
Acc.For.Debt	1012.1	2246.2	1995.8	1800.5	1635.2	1491.2	1349.4	
% GDP	22.6	48.1	38.9	30.1	22.9	19.3	16.5	
Interest Pay.	81.0	179.7	159.7	144.0	130.8	119.3	108.0	
% Tot.Exp.	19.4	35.3	19.7	13.4	9.2	7.6	6.2	
% GDP	1.8	3.8	3.1	2.4	1.8	1.5	1.3	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	630.4	659.5	669.5	694.5	711.0	723.1	1.5
Min	97.8	123.3	189.6	211.9	228.6	243.0	267.7	4.3
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	146.7	198.8	289.3	349.2	398.6	457.0	6.8
Pet	19.7	29.1	31.8	35.3	39.0	39.2	43.1	3.3
MCa	647.0	980.7	1452.8	2109.1	2374.5	2556.2	2721.5	6.2
MRe	1649.4	2032.2	2351.6	2681.5	3314.2	4050.2	4304.3	4.1
Con	608.3	665.6	603.1	616.1	631.0	638.0	692.1	0.5
Ele	78.9	201.1	250.8	285.7	301.7	322.7	347.5	6.4
Tra	404.8	623.9	763.5	867.6	944.3	1036.2	1110.2	4.3
Com	1261.9	1872.1	2124.4	2415.7	2489.9	2576.7	2546.2	3.0
Ser	1249.6	1577.1	1831.4	2138.3	2223.9	2240.8	2264.7	2.5
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.06	1.12	1.23	1.23	1.26	0.4
Mining	0.50	0.39	0.40	0.41	0.42	0.46	-0.4
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.62	0.47	0.50	0.51	0.55	0.56	-0.5
Petrochem	0.59	0.45	0.48	0.48	0.51	0.52	-0.6
M Capital	0.96	0.84	0.84	0.85	0.86	0.92	-0.2
M Rest	1.02	0.90	0.90	0.92	0.98	1.02	0.0
Construc.	0.91	0.73	0.54	0.58	0.61	0.64	-1.7
Elect.	1.14	0.93	0.92	0.89	0.85	0.81	-1.7
Transp.	0.67	0.56	0.59	0.58	0.56	0.50	-1.5
Commerce	0.82	0.79	0.66	0.62	0.54	0.52	-2.3
Services	0.86	0.80	0.74	0.69	0.60	0.60	-1.8
Governm't	0.77	0.68	0.68	0.65	0.63	0.55	-1.7
Agg. Cons.	0.919	0.835	0.807	0.801	0.788	0.780	-0.8
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.763	0.436	0.247	0.136	0.087	
% FERP	-6.5	-13.1	-13.2	-13.9	-10.6		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

2b) Low Domestic Energy Demand Scenario:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3396.2	3863.7	4456.0	5098.0	5501.3	5900.1	3.0
Investment*	1207.6	1405.6	1169.0	1200.8	1387.8	1454.4	1673.7	1.4
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	281.7	220.3	245.0	280.6	337.2	414.8	2.5
% Tot.Exp.	54.4	51.2	25.5	21.3	18.7	20.1	21.8	
Manuf. Exp.	89.2	158.6	524.4	776.5	1079.1	1192.6	1330.5	11.9
% Tot.Exp.	21.4	28.9	60.8	67.5	72.0	71.0	69.8	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	19.9	13.8	11.2	9.2	8.9	8.4	
Total Exports	418.2	549.7	863.1	1149.6	1497.9	1679.0	1906.6	6.5
Total Imports	528.1	1052.8	1156.3	1181.8	1173.7	1121.9	1367.2	4.0
Trade Deficit	90.9	503.1	293.2	32.2	-324.2	-557.1	-531.4	
GDP	4470.1	4783.3	5262.9	6189.9	7420.5	8172.2	8825.3	2.9
Foreign Bor.	-	1234.1	-290.8	-190.5	-175.0	-163.8	-144.7	
Acc.For.Debt	1012.1	2246.2	1955.4	1764.9	1589.9	1426.1	1281.4	
% GDP	22.6	47.0	37.2	28.5	21.4	17.5	14.5	
Interest Pay.	81.0	179.7	156.4	141.2	127.2	114.1	102.5	
% Tot.Exp.	19.4	32.7	18.1	12.3	8.5	6.8	5.4	
% GDP	1.8	3.7	3.0	2.3	1.7	1.4	1.2	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	672.4	702.8	710.6	736.8	752.9	759.9	1.7
Min	97.8	117.9	181.6	203.0	218.9	232.7	252.5	4.0
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	108.8	119.2	170.8	205.5	234.4	253.5	4.2
Pet	19.7	28.5	31.0	33.9	36.0	37.1	37.5	2.7
MCa	647.0	920.0	1373.1	2001.3	2217.2	2371.8	2507.9	5.8
MRe	1649.4	1915.1	2223.9	2520.4	3118.6	3822.4	4045.3	3.8
Con	608.3	711.0	630.4	642.9	661.7	690.0	747.1	0.9
Ele	78.9	149.4	188.4	209.1	228.2	234.4	235.9	4.7
Tra	404.8	532.7	651.7	729.5	832.1	877.5	914.0	3.5
Com	1261.9	1984.2	2251.5	2560.3	2638.9	2749.9	2812.3	3.4
Ser	1249.6	1741.8	2022.6	2361.0	2456.1	2562.3	2575.0	3.1
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.09	1.16	1.27	1.29	1.34	0.7
Mining	0.50	0.39	0.42	0.42	0.43	0.48	-0.2
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.62	0.43	0.47	0.47	0.51	0.51	-1.0
Petrochem	0.59	0.42	0.45	0.46	0.48	0.49	-1.0
M Capital	0.96	0.80	0.81	0.82	0.84	0.90	-0.3
M Rest	1.02	0.88	0.90	0.92	0.97	1.02	0.0
Construc.	0.91	0.73	0.57	0.61	0.64	0.67	-1.5
Elect.	1.14	0.93	0.92	0.89	0.86	0.83	-1.5
Transp.	0.67	0.56	0.60	0.59	0.57	0.52	-1.3
Commerce	0.82	0.79	0.68	0.65	0.62	0.55	-2.0
Services	0.86	0.80	0.77	0.71	0.66	0.63	-1.5
Governm't	0.77	0.68	0.67	0.65	0.64	0.57	-1.4
Agg. Cons.	0.919	0.826	0.812	0.806	0.801	0.793	-0.7
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.772	0.430	0.239	0.129	0.084	
% FERP	-6.3	-13.6	-13.7	-14.3	-10.2		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

7.5 Sensitivity to Alternative Weights on Terminal Assets

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3414.1	3845.9	4465.1	5170.4	5472.9	5548.5	2.7
Investment	1207.6	1385.8	1158.6	1173.1	1319.0	1413.6	1839.0	1.8
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.5	189.2	204.0	224.1	234.3	295.3	1.1
% Tot.Exp.	54.4	48.5	22.5	18.5	15.5	14.7	16.1	
Manuf. Exp.	89.2	163.5	531.8	771.5	1084.6	1210.0	1373.7	12.1
% Tot.Exp.	21.4	30.9	63.4	69.9	75.0	75.9	75.1	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	14.1	11.6	9.5	9.4	8.8	
Total Exports	418.2	530.4	839.4	1103.6	1446.9	1593.5	1830.3	6.3
Total Imports	528.1	1081.5	1187.8	1214.1	1203.8	1152.9	1446.3	4.3
Trade Deficit	90.9	551.1	348.4	110.5	-234.1	-440.6	-384.0	
GDP	4470.1	4733.4	5179.5	6093.0	7334.0	7986.5	8483.6	2.7
Foreign Bor.	-	1234.1	-271.2	-202.0	-221.6	-148.8	-205.1	
Acc.For.Debt	1012.1	2246.2	1975.0	1773.0	1551.4	1402.6	1197.5	
% GDP	22.6	47.5	38.1	29.3	21.4	17.6	14.1	
Interest Pay.	81.0	179.7	158.0	141.8	124.1	112.2	95.8	
% Tot.Exp.	19.4	33.9	18.8	12.8	8.6	7.0	5.2	
% GDP	1.8	3.8	3.1	2.3	1.7	1.4	1.1	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	662.0	693.6	701.2	714.2	723.4	734.2	1.5
Min	97.8	119.6	184.8	207.4	221.3	235.7	266.0	4.3
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	118.5	157.4	225.4	271.3	309.4	343.4	5.5
Pet	19.7	28.6	31.1	34.9	37.9	38.6	39.8	3.0
MCa	647.0	946.9	1417.3	2054.2	2288.9	2443.1	2672.9	6.1
MRe	1649.4	2001.8	2321.2	2629.8	3253.2	3984.2	4141.3	3.9
Con	608.3	688.1	610.1	622.1	640.3	647.0	807.3	1.2
Ele	78.9	170.2	214.2	237.7	260.5	271.0	274.8	5.3
Tra	404.8	579.3	708.7	793.3	904.8	954.1	992.9	3.8
Com	1261.9	1927.6	2187.3	2487.3	2563.7	2653.0	2604.5	3.1
Ser	1249.6	1641.3	1906.0	2225.3	2314.4	2415.5	2381.2	2.7
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.05	1.15	1.26	1.28	1.38	0.8
Mining	0.50	0.37	0.41	0.41	0.42	0.50	0.0
Oil	0.92	0.54	0.58	0.63	0.68	0.74	-1.1
Refining	0.62	0.46	0.49	0.50	0.56	0.57	-0.4
Petrochem	0.59	0.44	0.47	0.47	0.50	0.54	-0.4
M Capital	0.96	0.82	0.82	0.85	0.87	0.99	0.2
M Rest	1.02	0.88	0.91	0.94	0.99	1.07	0.2
Construc.	0.91	0.71	0.55	0.61	0.63	0.70	-1.3
Elect.	1.14	0.92	0.92	0.90	0.85	0.87	-1.3
Transp.	0.67	0.54	0.60	0.58	0.56	0.54	-1.1
Commerce	0.82	0.75	0.68	0.65	0.60	0.57	-1.8
Services	0.86	0.77	0.76	0.70	0.64	0.66	-1.3
Governm't	0.77	0.67	0.68	0.66	0.66	0.56	-1.6
Agg. Cons.	0.919	0.818	0.813	0.811	0.804	0.839	-0.5
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.774	0.432	0.240	0.130	0.080	
% FERP	-6.2	-13.6	-13.7	-14.2	-11.4		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

7.6 Sensitivity to Alternative External Debt Conditions:

1) Lower Initial External Debt Level:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3688.6	4218.4	4850.8	5548.0	127.1	6819.9	3.6
Investment*	1207.6	1342.4	1316.4	1440.0	1685.3	1778.3	1914.7	1.9
Government	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	252.8	183.3	200.3	218.6	222.7	288.6	1.0
% Tot.Exp.	54.4	49.1	22.6	18.3	16.7	14.5	16.3	
Manuf. Exp.	89.2	152.6	510.8	767.1	952.6	1167.9	1325.6	11.9
% Tot.Exp.	21.4	29.6	63.0	70.0	72.8	75.8	74.7	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	21.3	14.6	11.7	10.6	9.7	9.1	
Total Exports	418.2	514.8	812.5	1095.5	1309.4	1539.8	1775.5	6.2
Total Imports	528.1	963.6	1060.9	1102.2	1115.9	1055.4	1384.4	4.1
Trade Deficit	90.9	448.8	248.4	6.7	-193.5	-484.4	-391.1	
GDP	4470.1	5066.8	5809.8	6849.4	8037.3	9049.2	9737.8	3.3
Foreign Bor.	-	617.0	-209.3	-110.0	-105.2	-88.6	-71.3	
Acc.For.Debt	1012.1	1629.1	1419.8	1309.8	1204.6	1116.0	1044.7	
% GDP	22.6	32.2	24.4	19.1	15.0	12.3	10.7	
Interest Pay.	81.0	179.7	113.6	104.8	96.4	89.3	83.6	
% Tot.Exp.	19.4	34.9	14.0	9.6	7.4	5.8	4.7	
% GDP	1.8	3.5	2.0	1.5	1.2	1.0	0.9	

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	692.7	724.1	732.0	759.1	775.7	804.8	1.9
Min	97.8	127.8	196.8	219.9	237.1	252.1	275.6	4.4
Oil	292.2	391.7	353.2	392.5	436.2	471.1	499.4	2.3
Ref	95.2	124.1	164.9	236.2	284.2	324.1	372.3	5.8
Pet	19.7	29.5	32.9	36.0	39.2	40.7	42.4	3.2
MCa	647.0	871.4	1300.3	1885.2	2100.2	2242.0	2397.7	5.7
MRe	1649.4	2079.0	2414.2	2735.2	3383.6	4143.5	4450.4	4.2
Con	608.3	715.1	634.1	646.6	665.5	672.8	745.4	0.9
Ele	78.9	174.9	220.5	244.6	267.1	278.9	288.0	5.5
Tra	404.8	617.3	755.1	845.3	964.1	1016.7	1081.6	4.2
Com	1261.9	1992.9	2261.4	2571.6	2650.6	2741.9	2773.7	3.3
Ser	1249.6	1707.2	1982.5	2314.7	2407.4	2512.5	2524.0	3.0
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.08	1.14	1,26	1.29	1.33	0.6
Mining	0.50	0.39	0.41	0.43	0.43	0.44	-0.6
Oil	0.92	0.54	0.59	0.63	0.68	0.74	-1.1
Refining	0.62	0.47	0.49	0.51	0.56	0.59	-0.2
Petrochem	0.59	0.44	0.47	0.48	0.54	0.58	0.0
M Capital	0.96	0.84	0.86	0.87	0.92	0.96	0.0
M Rest	1.02	0.90	0.94	0.96	1.04	1.15	0.6
Construc.	0.91	0.74	0.56	0.60	0.70	0.88	-0.2
Elect.	1.14	0.92	0.92	0.89	0.92	1.04	-0.5
Transp.	0.67	0.57	0.59	0.59	0.60	0.61	-0.5
Commerce	0.82	0.78	0.70	0.69	0.62	0.64	-1.2
Services	0.86	0.79	0.78	0.75	0.72	0.72	-0.9
Governm't	0.77	0.67	0.67	0.65	0.65	0.56	-1.6
Agg. Cons.	0.919	0.839	0.825	0.832	0.846	0.871	-0.3
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.738	0.430	0.247	0.134	0.082	
% FERP	-7.3	-12.6	-12.9	-14.2	-11.6		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

2) Fall in Interest Rates and Increase in Oil Prices:

Table A
Main Macroeconomic Results, 1980-2004.
(1980 Billions of pesos)

Variable	1980	1984	1988	1992	1996	2000	2004	[%][1]
Consumption	2908.7	3404.0	3843.0	4483.4	5135.6	5551.3	5889.6	3.0
Investment*	1207.6	1392.6	1402.4	1638.5	1830.9	2030.1	2788.4	3.5
Government*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0
Oil Exports	227.6	257.7	189.3	200.3	223.3	231.4	262.8	0.6
% Tot.Exp.	54.4	48.6	22.8	18.2	15.7	14.8	15.2	
Manuf. Exp.	89.2	163.7	523.0	769.5	1064.1	1185.1	1300.8	11.8
% Tot.Exp.	21.4	30.8	63.0	70.1	74.6	75.7	75.4	
Exog. Exports	101.4	109.4	118.4	128.1	138.2	149.2	161.3	2.0
% Tot.Exp.	24.2	20.6	14.2	11.7	9.7	9.5	9.4	
Total Exports	418.2	530.8	830.7	1097.9	1425.6	1565.7	1724.9	6.1
Total Imports	528.1	1083.7	1178.2	1206.9	1201.4	1150.7	1398.9	4.1
Trade Deficit	90.9	552.9	347.5	109.0	-224.2	-415.0	-326.0	
GDP	4470.1	4728.3	5559.4	6578.2	7801.2	8655.8	9706.1	3.3
Foreign Bor.	-	1234.1	-209.4	-127.5	-126.1	-104.8	-124.1	
Acc.For.Debt	1012.1	2246.2	2036.8	1909.3	1783.2	1678.4	1554.3	
% GDP	22.6	47.5	36.6	29.0	22.9	19.4	16.0	
Interest Pay.	81.0	112.3	101.8	95.5	89.2	83.9	70.6	
% Tot.Exp.	19.4	21.2	12.3	8.7	6.3	5.4	4.1	
% GDP	1.8	2.4	1.8	1.5	1.1	1.0	0.7	

* Exogenous.
1 Average annual growth rate, 1980-2004.

Table B
Gross Output Levels, 1980-2004.
(1980 Billions of pesos)

Sec.	1980	1984	1988	1992	1996	2000	2004	[%][1]
Agr	510.5	658.3	688.2	695.7	721.4	737.2	753.9	1.6
Min	97.8	120.5	185.6	207.4	223.7	237.9	275.2	4.4
Oil	292.2	391.7	353.2	392.5	436.2	462.1	455.9	2.3
Ref	95.2	118.0	156.4	223.9	266.9	306.8	323.6	5.2
Pet	19.7	28.6	31.0	34.5	38.1	38.3	39.9	3.0
MCa	647.0	950.1	1419.4	2057.6	2292.4	2447.2	2459.0	5.7
MRe	1649.4	1984.6	2249.6	2543.0	3097.1	3770.8	4201.6	4.0
Con	608.3	693.6	702.1	737.1	754.6	772.6	836.5	1.3
Ele	78.9	167.0	210.6	233.7	255.1	266.4	274.8	5.3
Tra	404.8	579.9	709.5	796.7	908.0	960.1	1021.6	3.9
Com	1261.9	1983.8	2219.9	2525.1	2602.2	2692.5	2722.9	3.3
Ser	1249.6	1661.5	1916.7	2237.8	2327.4	2429.1	2451.6	2.8
Gov*	448.7	484.6	523.4	565.3	610.5	659.4	712.1	2.0

* Exogenous.
[1] Average annual growth rate, 1980-2004.

Table C
Shadow Prices, 1984-2004.
(1980 prices)

Sector	1984	1988	1992	1996	2000	2004	[%][1]
Agricult.	1.17	1.08	1.15	1.27	1.28	1.38	0.8
Mining	0.50	0.40	0.41	0.42	0.43	0.50	0.0
Oil	0.92	0.54	0.59	0.63	0.69	1.04	0.6
Refining	0.62	0.47	0.50	0.50	0.58	0.67	0.4
Petrochem	0.59	0.45	0.48	0.48	0.52	0.60	0.1
M Capital	0.96	0.83	0.84	0.85	0.90	0.92	-0.2
M Rest	1.02	0.88	0.92	0.95	1.01	1.08	0.3
Construc.	0.91	0.73	0.68	0.72	0.77	0.82	-0.5
Elect.	1.14	0.92	0.91	0.91	0.85	0.85	-1.5
Transp.	0.67	0.56	0.59	0.59	0.52	0.55	-1.0
Commerce	0.82	0.78	0.69	0.66	0.61	0.58	-1.7
Services	0.86	0.80	0.78	0.72	0.65	0.67	-1.2
Governm't	0.77	0.67	0.69	0.67	0.67	0.56	-1.6
Agg. Cons.	0.919	0.833	0.823	0.821	0.816	0.876	-0.2
FEN	1.0	1.0	1.0	1.0	1.0	1.0	
FERP	1.00	0.772	0.430	0.239	0.130	0.081	
% FERP	-6.3	-13.6	-13.7	-14.1	-11.2		

[1] Average annual growth rate, 1984-2004.
FEN = Foreign Exchange Numeraire.
FERP = Foreign Exchange Relative Price.
% FERP = Rate of change in FERP.

CHAPTER VIII.

SUMMARY AND CONCLUSIONS.

This study analyses three key aspects of the long-term relationship between energy policy and overall economic policy in Mexico: energy-industrialization; energy-labour force; and energy-foreign debt. An optimizing intertemporal general equilibrium model was constructed and implemented to analyze the interdependence between the decisions of the various economic agents, and to explore the sensitivity of optimal policies with respect to such key parameters as elasticities of substitution and world oil prices.

Two general classes of results have been obtained. The first refers to the solutions for real variables such as macroeconomic aggregates and sectorial output patterns. The second class of results relates to the implications for important prices as the time path for the real wage, the relative price of traded and nontraded goods, and the relation between the price of domestic goods and services and foreign exchange. Before presenting the conclusions derived from these results, there is, next, a summary of some of the findings of this work.

Chapter I analyzed how Mexican economic development has been determined by both energy and overall economic policy since the beginning of this century. It was seen that the integration of the energy sectors into the general development of the economy has not always been accomplished. Since the nationalization of the oil industry in 1938, the main objective of energy policy has been the satisfaction of the needs of the domestic market. This objective has been attained, except for the period 1971-74, when Mexico had to import crude oil and its derivatives. This objective, however, also meant stimulating economic growth through low energy prices which resulted in an income elasticity of domestic energy consumption greater than one in most periods.

From 1977 on, when the vast hydrocarbon discoveries were made, energy policy began to be oriented not only towards the domestic market, but to the generation of exportable surpluses as well. Above all, the over-optimistic expectations created by the oil boom permitted the government to postpone the correction of the various structural imbalances, thus contributing to the country's present economic woes. It was not until the oil and debt crisis that the government realized the need to speed up the transition from an economy based on hydrocarbon revenues and foreign borrowing, to an economy supported by the expansion of the domestic non-oil production. Several of the recent measures taken by the authorities in this respect were mentioned such as the import liberalization and export promotion programmes and the adhesion of Mexico to the GATT.

It the light of the historical analysis, chapter II discussed the key long-term development issues that Mexico faces as a country with oil, and which represent the questions considered in this dissertation. Chapter III then reviewed some of the most representative theoretical and quantitative energy models.

With respect to quantitative energy models, chapter III separated the research carried out before and after the oil boom of 1973-74. Before this period, applied energy studies basically consisted of either econometric or I-O models, and the majority employed partial equilibrium methods. After the first oil boom, a reappraisal of the energy situation and the capabilities of existing models, both theoretical and applied, became essential. Regarding theoretical models, special attention was given to those studies that analyze the impact of exogenous resource flows on the structure of the economy. These theoretical models provided the basic framework for the evaluation of the Mexican economy by showing how changes in the level of exogenous resources (i.e. oil and gas revenues and net foreign capital inflows) were expected to affect relative prices and,consequently, the resource allocation between traded and nontraded goods.

Post-oil boom quantitative models are divided according to three categories of questions. The first category of questions and models deals with the energy resource as an input to production. A second category relates to natural resources as the source of revenue to the economy, and it was seen that such type of models are essentially static. The third class of issues arise from the fact that the supply of hydrocarbons is finite, so that time plays a critical role, as is the case in the optimizing model presented here. These three types of questions can be approached within a CGE or optimizing frameworks. Chapter III assessed the pros and cons of both approaches. Briefly, CGE models are better in analyzing price, tax and subsidy issues, while optimization models treat intertemporal issues in a more satisfactory manner. Yet, both types of approaches are general in scope and take energy-economy interactions fully into account.

The SAM approach to modeling was employed with two aims in Chapter IV. First, it was useful for comparing the structure and specification of three GE studies for Mexico (i.e. Serra Puche, 1979; Reyes Heroles, 1982; and Blitzer and Eckaus, 1986a). These models were compared according to: classification of accounts, behavioural assumptions and characteristics, data base and closure rules. Such analysis was then used to evaluate the present model in relation to those three studies. The present model is disaggregated into 13 production activities (6 non-tradeables, 4 tradeables and 3 oil-related sectors). It contains 9 goods and services and 16 primary inputs: 3 labour groups and 13 sector-specific capital stocks. With respect to (B-E), which served as the starting point of this work, five basic modifications to the classification of accounts are incorporated because of the particular hypothesis and experiments of this research:

(a). The labour force is divided into three main groups: rural, skilled and unskilled urban.

(b). The refining and petrochemical sectors are separated.

(c) The manufacturing sector is split into its two main components: capital goods and the rest.

(d). Mining constitutes a single sector.

(e). Commerce and services sectors are divided.

Also, based on the SAM framework, the within period behavioural equations of the model were described. It was shown that every account in the SAM is balanced, that is, the model is complete in the sense that all incomes and outlays are fully accounted for. A static model, on the other hand, sets exogenously several important long-range questions of macroeconomic planning, such as investment expenditures and oil exports. For this reason, the numerical solution of the model was implemented to the multi-period system.

Chapter V thus, described the intertemporal equations that are required in addition to the SAM equations so as to determine endogenously the above-mentioned key variables, which are optimal within and amongst the discrete time horizon. The planning horizon of the model covers a twenty-eight year time period from 1980 to 2008, divided into equal sub-periods of four-years length. This plan horizon is regarded as appropriate because it takes some time for the impact of relative price changes to be fully reflected in the economy. In addition, investments in energy and other sectors are long-lived.

Social Welfare is approximated by maximizing the discounted present value of the sum of aggregate consumption along the planning horizon of the model and terminal net wealth. This specification of the maximand differs from previous studies of this kind, and it satisfies the conditions for a finite-horizon plan to be optimal such as the convexity of the consumption set and the specification of terminal conditions on Mexico's wealth assets: capital stocks, oil and gas reserves, and foreign debt. Above all, this objective function proved to be successful in the sense that the overall results of the model are satisfactory, including the behaviour of the various intertemporal shadow prices, which was not the case, for example, in the model developed by (B-E).

In addition to the above-mentioned differences, other improvements incorporated to the model refer to the specification of some behavioural equations as well as to the data base and the software employed:

(1) While in (B-E) nonlinear production functions had to be approximated by prespecifying certain substitution activities for some sectors on the basis of fixed coefficients, in the present study value added is generated through truly price-sensitive technologies as C-D and CES for all sectors. These production functions led to more attractive price structures than those generated by piece-wise approximations.

(2) Price-sensitive consumption demand functions are also incorporated directly into the model through ELES so that the substitution possibilities between consumption expenditures had not to be prespecified as in (B-E).

(3) The model determines endogenously competitive and non-competitive imports, foreign borrowing and repayment costs, oil and gas depletion, and it calculates the efficient level and sectorial composition of investment, consumption and production. Further, it decides the optimal composition of exports between oil and the two

types of manufacturing goods. The latter are considered as exogenous in (B-E).

(4) The 1980 I-O Table which serves as the main data base of the model is the most updated that exists for Mexico and it identifies more accurately the different oil related activities than previous matrices.

(5) GAMS and in particular MINOS 5.0 allowed to disaggregate the SAM accounts and the plan horizon of the model in the manner described previously, as well as to introduce nonlinear equations into the system. This software also provides a more precise solution than previous algorithms.

Conclusions:

As already stated, the long-run optimal growth model developed in this work was used to analyze some of the fundamental macroeconomic challenges faced by the Mexican economy over the next two decades. While there is a great deal of uncertainty relating to world oil prices and other exogenous variables, it is nonetheless possible to derive the following conclusions from the primal and dual results of the several experiments reported in chapters VI and VII, which can serve as guidelines to development strategy in Mexico:

Primal Results:

(1) Revenues from hydrocarbons and foreign borrowing represent very special kinds of income because they imply decumulation of wealth unless they are converted into other productive assets. They can be viewed as a transfer to the economy not based on domestic production. In order then to secure the continuity of income, Mexico must shift the structure of growth from its dependence on these "exogenous resources", to a self-sustaining

economy. This transition requires the rapid expansion of domestic goods and services, particularly non-oil tradeables, so that foreign exchange comes primarily from industrial exports.

(2) This structural adjustment process requires that a big proportion of investment be directed towards export expanding and import-substituting activities. Similarly, factor accumulation (both capital and labour), intermediate inputs, consumption and other sources of change will have to work in that same direction. Moreover, over the next twenty years the growth of non-oil exports, specifically manufacturing, will have to be well above GDP and imports growth. This result, then, supports the government's decision to increase the efficiency and the exposure of domestic industry to international markets.

(3) Yet, even if these structural changes are undertaken, the various solutions of the model suggest that they would not be enough for the economy to create the jobs required to absorb the labour force, which is expected to grow at 3.6 percent per year in the near future. In effect, the average annual GDP growth ranges from 2.1 percent obtained when a CES technology with substitution elasticities below one is specified and unemployment of unskilled labour is the outcome, to 3.3 percent when a lower initial debt level is assumed.

(4) This poor performance of the Mexican economy is mainly due to the external debt burden. In all the

various experiments, the model considers the level of accumulated foreign debt as excessive, in so far as it chooses to make principal payments from 1984 on. Foreign debt reduction is then the most profitable way of allocating current income which implies a portfolio switching effect against investment in real capital assets, thus restricting severely the growth of the economy.

(5) The portfolio switching effect among the assets that constitute Mexico's wealth also calls for decumulation of oil and gas reserves. In fact, the optimal pattern of hydrocarbons production is in most cases severely constrained by the fixing of production ceilings at the levels imposed by the authorities. Unless either proven hydrocarbon reserves become a constraint (i.e the ratio of reserves to production gets below 12 years by the end of the year 2004), or there are much favourable external conditions in the form of both higher expected world oil prices and lower interest rates on foreign debt, the model sets oil and gas production at the maximum levels throughout.

(6) Skilled labour force shortages also restrict the economy significantly. When a minimum skilled labour to output ratio is required (i.e. the substitution elasticities are below one), the model shows the lowest rates of growth for the main macroeconomic variables as well as a more depressed sectorial growth than in any other scenario, particularly for skilled labour intensive

industries such as petrochemicals, refining and electricity. Yet, the economy is not constrained in its ability to absorb oil revenues.

(7) An increase in domestic energy consumption reduces the amount of oil and gas that is available for exports, and puts the economy under significant stress. Policies, therefore, must be implemented encouraging the conservation and efficient use of energy. Because of their dynamism and intense energy use, the following sectors are the best candidates for that purpose: transport, metallurgy, steel and other manufacturing industries, and the energy sectors themselves (oil and gas, refining, petrochemicals and electricity).

(8) Despite the fact that an analysis of energy pricing policy was not one of the objectives of this research, it is clear that energy conservation programmes should take into account, among other factors, the relationship between domestic and international prices, as well as between Pemex prices and production costs. In addition, it is of great importance to diversify the energy sources used to generate electricity since currently hydrocarbons account for about 90 percent of primary energy production.

Dual Results:

(9) The non-recursive dynamic approach to shadow pricing and the resulting use of a relative shadow price

structure that changes over time is the appropriate framework for analyzing structural changes in an economy.

(10) In order to evaluate the price adjustments required by the long-term structural adjustment process, it is also important to distinguish between the internal (PNT/PT) and the external (price of domestic goods vis-a-vis imports) real exchange rates. The former captures the degree of difference between tradeables and non-tradeables in terms of the mix of factors of production, while the external terms issue depends on the external competitiveness of an economy.

(11) The price counterpart of a reduction in external resources in an economy and the consequent structural adjustment process described previously, is the real depreciation of the internal exchange rate, so as to facilitate substitution away from traded goods in consumption and towards them in production, as well as a gain in external competitiveness (i.e. a fall in domestic prices compared to international prices).

(12) Foreign exchange is the most serious constraint of the economy. With the exception of some traded commodities such as agricultural and the two manufacturing goods, and to a lesser extent, electricity, foreign exchange worths more than a unit of any other domestic good and service in most time periods. The whole system is thus more productive when the foreign exchange constraint is loosened, as shown by the results of a reduction in the level of accumulated foreign debt.

(13) These results, then, support the view that debt and/or debt service reduction, together with the returning of capital flight, are indeed necessary if the problem of growth and debt payments is to be reconciled. In other words, unless Mexico can achieve growth in output and in per capita income, the prospects for principal and interest payments will deteriorate.

(14) The skill-mix differs substantially among alternative investment projects in Mexico. It is then essential to separate by skill categories in order for an economy-wide model to generate meaningful criteria for project decisions.

(15) According to the results of the model, the efficiency price differentials among skill groups are favourable to skilled labour. On average, rural and urban unskilled wages represent about one-third and half of urban skilled wage, respectively, throughout the model's plan period. This simply reflects the fact that skilled labour is the most demanded and relatively scarce group. Thus, the whole economy would be more productive if the availability of skilled labour is increased, particularly if substitution between skills is difficult or not possible, as shown by the case of CES functions with elasticity values below one.

The research that has been described in this study could be carried further in various ways. The first is uncertainty. As indicated in section 6.2 all decisions in the model are made with perfect information about the future price of oil, hydrocarbon reserves, interest rates, and so forth. Yet, uncertainty about these variables plays a crucial role in determining the depletion rate of hydrocarbons, and influences the allocation of resources. Although sensitivity analysis with respect to assumptions about the future pattern of some of these variables has provided some information, some form of stochastic decision-making should be incorporated into the system. Extending the current methodology to take into account such uncertainty is perhaps the most important area for future research.

The second issue refers to the behaviour of the oil market. Most energy GE models take the world oil market as exogenous, so that in order to gain some insights about the way this market works, it is essential to model explicitly its behaviour.

A third, and related issue, consists in introducing to GE models non-competitive behaviour, externalities, technological change, and various forms of rationing which exist in a real world economy.

To conclude, intertemporal optimizing GE models represent nowadays an indispensable tool for the analysis of development planning. Yet they are, in many ways, only the beginning of policy making. Further work on this area, therefore, should be encouraged.

APPENDIX A.

NUMERICAL SPECIFICATION OF THE MODEL.

This Appendix refers to the data used to solve the base run of the model [1]. It describes the selection of the base year; the data for the objective function; and the estimates for the structural parameters and constraints.

(1). Base Year.

In specifying the model numerically 1980 was chosen as the base year. 1980 represents a plausible choice of base year because, as noted in chapter I, during the 1978-82 period, the economy of Mexico experienced a sustained economic growth as well as a moderate inflation. Also, as explained in section 4.2, the 1980 I-O matrix, which is the main data source of the model, represents the most recent data base that exists for Mexico and it takes account of the effects of the oil boom on the whole Mexican economy up to that year.

(2). Objective Function.

As indicated in section 5.2, what is maximized is the present value of the aggregate consumption stream subject to terminal net worth. The data needed in the estimation of the objective function, therefore, refers to the ELES as well as the exogenous terminal year prices of the three sets of assets that constitute Mexico's wealth

---

[1] Chapter VII, describes the data needed to carry out the different experiments as well as for testing the model behaviour or sensitivity analysis.

(i.e. capital stocks, oil and gas reserves, and foreign debt).

To begin with, yearly consumption is defined in per capita terms so that it has to be multiplied by population ($\bar{N}_t$) to obtain total consumption during the model's time horizon. This information was obtained from projections made by STyPS (1977), which assumes that the population will grow at an annual average rate of 2.3 percent during 1980-2008. These projections are reported next:

Table A.1
Total Population in Mexico, 1980-2008
(Millions of Persons)

Year	$\bar{N}_t$
1980	69.655
1984	76.308
1988	82.839
1992	89.538
1996	96.578
2000	103.996
2004	111.651
2008	119.348

Source: STyPS (1977, p.2)

On the other hand, the ELES contains three parameters: the marginal expenditure shares on consumption per good (v_i); the minimum level of per-capita consumption per good (c_i); and the four-year rate of time preference of utility (δ). The latter parameter was assumed to be 10 percent in the base run of the model, but it was later modified (see section 7.4); while v_i and c_i were obtained from econometric estimation carried out by Garcia Alba

(1986) for the 1960-1981 period, using Mexican data [2]. His estimation is based on the assumption of a representative consumer, and on the disaggregation of the economy into 14 sectors. With the exception of mining, refining and petrochemicals, the sectorial classification was similar to the one used here [3]. The values of v_i and c_i are as follows for the base run [4]:

Table A.2
Parameters of the ELES

Sector	v_i	c_i [1]
Agriculture	.0930	1.2240
Mining	.0001	0.0006
Refining	.0240	0.2450
Man. capital	.0410	0.7780
Man. rest	.3206	6.4900
Electricity	.0160	0.0980
Transport	.0659	1.6380
Commerce	.2494	5.5490
Services	.1900	4.2130
	1.0	

[1] In 1980 billions of pesos per capita.
Source: Garcia Alba (1986).

Moving now to the estimation of the price of the terminal assets and beginning with capital stock prices (PKi,7), Taylor et al. (1975) and Dervis et al. (1982) state that these prices reflect a rather arbitrary judgment because neither planners nor markets enjoy perfect foresight, so that it is not possible to predict

[2] This was the only reliable estimates that were found for these two parameters. For the analysis of the econometric results of the estimation see the reference.
[3] The parameters for these three sectors were approximated using the 1983-84 Households Survey.
[4] See section 7.4 for a description of alternative values of the marginal expenditure shares.

exactly what these prices will be in the future. In other words, there is no perfect way to calculate $PK_{i,7}$.

One possibility is that for traded capital goods, they can be set equal to projected world prices appropriately discounted. Unfortunately for non-traded capital goods this is not possible. An alternative procedure adopted here is to take advantage of the fact that an optimizing model yields shadow prices associated with each constraint, including capital capacity constraints.

It is important to recognize, however, that these shadow prices are those generated assuming perfectly competitive markets throughout the economy, all with perfect foresight (i.e. there is no uncertainty). That is, the shadow prices generated by an optimizing model implicitly assume an efficient resource allocation or marginal costs = marginal benefits for activity undertaken. In this sense, the dual and market mechanisms are similar since they achieve the same result: reducing to zero the value of excess demand for every input.

Obviously, in a real world economy with many distortions and imperfect markets, there are prices in excess of marginal costs, etc. Nonetheless, a real world economy cannot depart very much from market forces if maximization of Social Welfare is to be achieved. Real world capital stock prices thus, should approximate efficiency or shadow prices.

Efficiency, on the other hand, is only approximated in an optimizing model. As Bell and Srinivassan (1983) point out, to the extent that the activities of an optimizing model reflect the choices made by the different economic agents, and the objective function is social welfare, then shadow prices in general, and in particular, the efficiency prices of the capital capacity constraints will represent the true welfare-detecting, second-best shadow prices.

As indicated in section 3.3, Martin and van Wijnbergen (1986) have also shown that shadow prices derived in an intertemporal forward-looking optimization approach can be used in project evaluation. In particular, this approach sheds light on the rate at which the shadow price of capital changes over time (accounting rate of interest), so that it is possible to determine current and future value of capital (see also Devarajan, 1988). A similar procedure was adopted here:

Firstly, a LP version of the model was run without terminal conditions on capital stocks [5]. Obviously, with this specification there was no investment in either sector during the terminal-year of the model [6]. The

---

[5] This LP version of the model included Leontief production functions instead of a C-D technology, as well as three linear consumption equations replacing the ELES. The remaining equations are identical to the complete NLP model including the maximand, with the exception that terminal wealth omitted the value of capital stocks. Section 5.3 analyses the differences between the LP and the NLP models from the computational standpoint.

[6] In order to 'force' the model to make terminal-year investment expenditures, an alternative LP model was run in which the terminal conditions on capital stocks were determined assuming a minimum level for investment (terminal year investment was set equal to 0.3 of the sum of investment in prior periods). However, the results in terms of

capital stocks shadow prices which resulted from the optimal solution of the LP model for the 1984-2004 period were employed as a proxy to extrapolate $\overline{\overline{PK}}_{i,7}$. These prices properly discounted (at a rate i) are then incorporated into the objective function of the complete NLP model [7].

The LP's shadow prices for the thirteen capital stocks decreased over time with the traditional investment sectors (i.e construction and manufacturing of capital goods) showing the highest values throughout [8]. The same holds for $\overline{\overline{PK}}_{i,7}$ as can be in Table A.3.

Table A.3
Sector-Specific
Capital Stock Price, 2008

Sector	$\overline{\overline{PK}}_{i,7}$
Agriculture	0.599
Mining	0.290
Oil and Gas	0.274
Refining	0.296
Petrochemicals	0.306
Man. Capital	0.637
Man. Rest	0.433
Construction	1.108
Electricity	0.224
Transport	0.348
Commerce	0.528
Services	0.502
Government	0.214

Turning now to the estimation of the terminal world oil price (qr), again, there is no perfect way to predict

the shadow prices of the capital stocks were very similar to the original LP model.

[7] Tourinho (1985), also estimated the exogenous terminal capital stock prices on the basis of some preliminary runs, obtaining satisfactory results in terms of both primal and dual results.

[8] The fact that the shadow prices for capital stocks decrease over time simply means that it is better to have an extra unit of capital sooner rather than later. Further implications of the shadow prices are analyzed in section 6.4.

exactly the future path of real oil price. In the base run of the model (see chapter VI), it is assumed that oil prices increase at 2 percent per year in real terms from 1992 to 2008 [9]. This rate of growth applied to the observed figure for 1988 [10], properly discounted, is introduced into the objective function, which together with the endogenous terminal level of reserves determines the social valuation for hydrocarbons (qr R_7).

Regarding the terminal-year value of accumulated foreign debt (qd D_7), it is simply the value calculated endogenously by the model. That is, the shadow price for terminal foreign debt (qd) is equal to one (foreign exchange rate is the numeraire of the system), which once discounted, it is introduced into the objective function.

(3). Structural Parameters and Constraints:

This subsection examines the way in which the parameters and exogenous variables appearing in each constraint of the model are calculated.

Material Balances:

This equation contains no parameters and a single exogenous variable: government expenditure ($\bar{G}_{i,t}$). However, some of the exports of goods ($E_{i,t}$) were also determined exogenously. The calculations of these non-

---

[9] The World Bank's (1984) "official" world oil price scenario estimates a 3 percent real growth until the early 1990's and a gradual decline thereafter. Recent developments in the oil market, however, suggest a more pessimistic scenario for oil producers.
[10] The 1988 oil price figure is taken from SHCP (1988). This and the complete oil price pattern for the Base Run of the model is described in dollar terms further down.

parameter estimates are described in section 6.1 for the Reference Case of the model.

Foreign Exchange Balance:

This equation (across sectors) needs for its solution, information about three parameters: the price of competitive imports and exports by sectors and by time periods ($pm_{i,t}$ and $pe_{i,t}$), and the price of non-competitive imports across sectors and by time periods (pnm_t). This information was obtained from the Ministry of Finance (1987). It covers the 1980-86 period and is set up by quarters, so that there was need to get the average for 1984. Starting with competitive imports, they are allowed in five sectors: agriculture, mining, refining and the two manufacturing sectors. Also, distinction between the price of the two petroleum products and between the two manufacturing goods could not be achieved with the information source used, so it was necessary to assume the same pattern of import prices. The value for 1988 corresponds to the average observed during 1985 and 1986. From 1992 onwards, the annual average growth rate of the 1980-86 period was employed for each sector.

Table A.4
Price Index of Competitive Imports, 1984-2004
(1980=1)

Sector	1984[1]	1988[1]	1992	1996	2000	2004
Agricul.	1.1815	0.8781	0.9132	0.9498	0.9874	1.0273
Mining	1.0972	1.1154	1.1600	1.2064	1.2547	1.3049
Refining	1.5472	1.1391	1.1847	1.2321	1.2813	1.3326
Man.cap.	1.1272	1.3243	1.4302	1.5447	1.6682	1.8017
Man.rest	1.1272	1.3243	1.4302	1.5447	1.6682	1.8017

1 Obtained from SHCP (1987). The figures for 1988 correspond to the average of 1985 and 1986.

Regarding export prices, the price index of the exogenously given export sectors is one throughout the model's time horizon. On the other hand, the pattern of Mexico's oil price in terms of dollars is as follows: 1984 = $26.39; 1988 = $15.53; 1992 = $16.77; 1996 = $18.11; 2000 = $19.56; 2004 = $21.13; 2008 = $22.82. The 1984 and 1988 are observed values, while from 1992 onwards a 2 percent annual increase in real terms was assumed [11]. The same assumption follows for the export price index of the two manufacturing sectors. Again, no distinction could be made between the price index of the two manufacturing goods.

Table A.5
Price Index of Exports, 1984-2004
(1980=1)

Sector	1984[1]	1988	1992	1996	2000	2004
Agricul.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Mining	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Oil	0.9214	0.5426[2]	0.5860	0.6329	0.6835	0.7382
Refining	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Petroch.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Man.cap.	0.9590	0.8340	0.8674	0.9021	0.9381	0.9757
Man.rest	0.9590	0.8340	0.8674	0.9021	0.9381	0.9757
Transp.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Commerce	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

[1] Obtained from SHCP (1987).
[2] Price of oil observed during June 1988.

Finally, the price index of non-competitive imports across sectors is a weighted average of all imports, the weights being the share of each sector in the total. From 1992 onwards a growth rate of about 1 percent per year in real terms was supposed.

[11] See Figure 7.4 of chapter VII for a description of alternative oil price scenarios.

Table A.6
Price Index of Non-Competitive Imports, 1984-2004
(1980=1)

Year	pm_t
1984[1]	1.2314
1988	1.1025
1992	1.1466
1996	1.1925
2000	1.2402
2004	1.2898

[1] Obtained from SHCP (1987).

Production Technology and Input Demand:

Three sets of equations determine the production behaviour of each sector. The first corresponds to the C-D specification, which includes two sector-specific types of parameters: the constant shift parameter ($\bar{A}_i$), and the input share parameters (α's). $\bar{A}_i$ was calculated via benchmarking procedures employing the 1980 I-O Table.

With respect to the α's, it was assumed that value added from capital and labour is the result of the long-run equilibrium and, therefore, the assumption of constant returns to scale implies that $\Sigma\alpha_{i,s}$ and $\alpha_{i,4}$ are given by the shares of labour and capital in value added net of taxes, shown in the 1980 I-O Table. The disaggregation of $\alpha_{i,s}$ by skill categories was then computed using statistics from the Ministry of Labour (STyPS, 1982) about the participation of each type of skill in the total labour employed by each industry [12]:

[12] Section 7.1 presents the values of the elasticities of substitution of the CES forms.

Table A.7
Parameters of the Cobb-Douglas
Production Functions *.

Sector	$\bar{A}_i$	$\alpha_{i,1}$	$\alpha_{i,2}$	$\alpha_{i,3}$	$\alpha_{i,4}$
Agricul.	0.378	0.187	0.064	0.002	0.747
Mining	1.017	0.031	0.166	0.155	0.648
Oil	0.871	0.015	0.181	0.024	0.780
Refining	2.497	0.040	0.520	0.070	0.370
Petroch.	2.099	0.042	0.557	0.076	0.325
Man.cap.	1.282	0.054	0.328	0.049	0.569
Man.rest	1.136	0.039	0.242	0.036	0.683
Const.	2.223	0.107	0.421	0.119	0.353
Elect.	0.564	0.027	0.428	0.092	0.453
Transp.	1.148	0.051	0.253	0.037	0.659
Commerce	0.954	0.030	0.044	0.165	0.761
Services	1.071	0.103	0.205	0.185	0.507
Governm.	1.326	0.241	0.345	0.411	0.003

* Constructed using data from 1980 I-O Table (SPP, 1986).
1 = Rural labour. 3 = Non-skilled urban labour.
2 = Skilled urban labour. 4 = Capital.

The second and third sets of production equations refer to the demand for intermediate inputs and non-competitive imports. The former contains a single parameter: the fixed-technical coefficients ($a_{i,j}$), which are directly obtainable from the 1980 I-O or A matrix [13]. The latter, on the other hand, has two sector-specific parameters: the non-competitive import demand per unit of output (nm_i), and per unit of investment (nmc_i). The first of these parameters was also directly calculated from the A matrix, whereas nmc_i was computed from the capital-share or B matrix [14]:

[13] The technical coefficients matrix can be seen in the computer programme shown in Appendix B.
[14] The B matrix was estimated using Banco de Mexico (1986) statistics, which follow the disaggregation procedure of the I-O matrix. Banco de Mexico's information is based on industrial surveys and covers the 1960-85 period.

Table A.8
Non-Competitive Import Demand per unit of Output and Investment.

Sector	nm_i[1]	nmc_i[2]
Agriculture	0.008	0.163
Mining	0.020	0.250
Oil	0.012	0.274
Refining	0.031	0.372
Petrochem.	0.059	0.300
Man.capital	0.133	0.237
Man.rest	0.073	0.200
Construction	0.034	0.231
Electricity	0.017	0.114
Transport	0.068	0.124
Commerce	0.002	0.027
Services	0.004	0.027
Government	0.011	0.000

[1] Obtained from 1980 I-O Matrix (SPP, 1986).
[2] Obtained from Capital Matrix constructed for 1980 using data from Banco de Mexico (1987).

Labour Market:

As explained in section 4.2, the labour supply of each category is exogenously determined, for the six time periods of the model ($\bar{\bar{LS}}_{s,t}$). Base year data for this variable is published in the 1980 Population Census. Thereafter, it was assumed a different annual rate of growth for each labour category, according to projections made by STyPS (1977). These rates were then applied to each initial vector of labour supplies to get their estimated levels.

Table A.9
Projected Labour Supply, 1984-2004 *
(Millions of Persons)

Category	1984	1988	1992	1996	2000	2004
Rural	8.444	9.727	11.205	12.908	14.869	17.129
Urban-skil	10.110	11.557	13.211	15.101	17.262	19.732
Urban-unsk	6.840	7.940	9.217	10.700	12.422	14.421

* Obtained from estimates made by STyPS (1977).

Capital Capacity Constraints:

These sector-specific equations employ two parameters and one exogenous variable. The parameters are the four-year depreciation rates of capital stocks (d_i), and the four-year gestation lags (f_i); whereas the exogenous variable corresponds to the vector of base-year sectorial capital stocks in gross terms ($\bar{K}_{i,0}$). Data for d_i and $\bar{K}_{i,0}$ was taken from figures published by Banco de Mexico (1986). This information, however, excludes the agricultural sector, and therefore, it was necessary to approximate its value using the National Accounts for 1988.

On the other hand, f_i was assumed to be the same as those calculated by (B-E) in their study for 1977. This was necessary because no other reliable estimates of f_i were found. The scalar of total base-year investment was also obtained from National Accounts ($\bar{I}_0$ = 1202.8 bp). The parameters and $\bar{K}_{i,0}$ are shown below:

Table A.10
Capital Stocks, Depreciation Rates, and Gestation Lags by Sectors.

Sector	$\bar{K}_{i,0}$[1]	d_i[1]	f_i[2]
Agricul.	1021.048	0.02	2.00
Mining	73.365	0.03	4.00
Oil	575.539	0.03	4.50
Refining	118.006	0.02	4.00
Petroch.	17.473	0.02	4.00
Man.cap.	705.281	0.03	3.00
Man.rest	1797.800	0.03	3.00
Const.	79.077	0.04	1.25
Elect.	379.620	0.02	5.00
Transp.	368.394	0.02	3.00
Commerce	1564.807	0.03	2.00
Services	1549.525	0.03	2.00
Governm.	1018.649	0.00	3.00

[1] Obtained from Banco de Mexico (1987). $K_{i,0}$ is in 1980 billions of pesos.
[2] Obtained from Blitzer and Eckaus (1983, p.95).

Investment:

Investment is endogenously calculated through a fixed-coefficients matrix which captures investment expenditures by both sector of origin and sector of destination ($b_{i,j}$). As already noted, this capital share matrix was estimated through Banco de Mexico's (1986) statistics. The only problem consisted in estimating the corresponding figures for the agricultural sector given that this sector was not included in the survey. In this case the coefficient was obtained from National Accounts. The capital share matrix can be seen in the Appendix B.

Finally, the non-parameter estimates appearing in the three sets of equations determining Oil Reserves and Extraction Levels, as well as Foreign Borrowing and Debt Service are discussed in section 6.1 as part of the Base Run of the model.

In summary, most of the data has been calculated from official data with a large sampling, or from private studies whose estimation techniques are in our view appropriate. In certain cases, however, the value of some parameters has been approximated according to theoretical considerations and intuition. Thus, the effects of mispecification in these parameters on model results are a cause of concern. Chapter VII, therefore, analyzed the sensitivity of model results with respect to variation in parameters which were not estimated from a data base.

APPENDIX B.

```
FILE: BARBA    GAMS     A    *** UNIVERSITY OF WARWICK ***

$ TITLE MASIOSARE, OPTIMIZING ENERGY GE MODEL, 1980-2008
$STITLE INTRODUCTION
*  THIS IS THE BASE RUN OPTIMIZING GE MODEL
*  FOR ANALYZING ENERGY-ECONOMY INTERACTIONS IN MEXICO, 1980-2008.

 SET TM        LABELS APPEARING IN THE TRANSACTION MATRIX   /

               AGR          AGRICULTURE, FORESTRY, DAIRY AND FISHERIES
               MIN          MINING (EXCLUDING PETROLEUM)
               OIL          OIL AND GAS EXTRACTION
               REF          REFINING PRODUCTS
               PETR         PETROCHEMICAL PRODUCTS
               MCAP         MANUFACTURING OF CAPITAL GOODS
               MREST        MANUFACTURING OF CONSUMPTION &INTERMEDIATE GOODS
               CONST        CONSTRUCTION
               ELEC         ELECTRICITY
               TRANS        TRANSPORT
               COM          COMMERCE
               SER          SERVICES
               GOV          GOVERNMENT SERVICES

               TOT-I-D      TOTAL INTERMEDIATE DEMAND
               IMPORTS      NON-COMPETITIVE IMPORTS
               TOT-INT      TOTAL INTERMEDIATE INPUTS
               CAPITAL      CAPITAL VA
               LABOUR       LABOUR VA
               TOT-VA       TOTAL VALUE ADDED
               IND-TAX      INDIRECT TAXES
               TOT-INPT     TOTAL INPUTS AND VALUE ADDED

               PRV-CON      PRIVATE CONSUMPTION
               GOV-CON      GOVERNMENT CONSUMPTION
               INVEST       TOTAL INVESTMENT
               EXPORTS      EXPORTS
               TOT-F-D      TOTAL FINAL DEMAND
               TOT-OUT      TOTAL OUTPUT           /

$STITLE SET DEFINITIONS
 SET TE          PLAN HORIZON          / 1980, 1984, 1988, 1992,
                                         1996, 2000, 2004, 2008 /

     T(TE)     OPTIMIZATION HORIZON  / 1984, 1988, 1992, 1996, 2000, 2004/

     JD(TM)     SECTORS OF DESTINATION USED IN DATA ESTIMATION  /
                AGR, MIN, OIL, REF, PETR, MCAP, MREST, CONST, ELEC,
                TRANS, COM, SER, GOV, PRV-CON, GOV-CON, INVEST, EXPORTS /

     J(TM)      INPUT-OUTPUT SECTORS OF DESTINATION /
                AGR, MIN, OIL, REF, PETR, MCAP, MREST, CONST, ELEC,
                TRANS, COM, SER, GOV  /

     ID(TM)     SECTORS OF ORIGIN USED IN DATA ESTIMATION  /
                AGR, MIN, OIL, REF, PETR, MCAP, MREST, CONST, ELEC,
                TRANS, COM, SER, GOV, IMPORTS, TOT-INT, CAPITAL, LABOUR,
                TOT-VA, IND-TAX, TOT-INPT  /

     ICI(TM)    ROW LABELS FOR TRANSACTIONS MATRIX  /
                AGR, MIN, OIL, REF, PETR, MCAP, MREST, CONST, ELEC,
                TRANS, COM, SER, GOV, IMPORTS, TOT-VA, IND-TAX   /
```

```
IC(J)      PRIVATE CONSUMPTION SECTORS / AGR, MIN, REF,
           MCAP, MREST, ELEC, TRANS, COM, SER /

IM(J)      COMPETITIVE IMPORT SECTORS  / AGR, MIN, REF, MCAP, MREST /

HYD(J)     HYDROCARBON EXPORTS         / OIL  /

MANC(J)    MANUFACTURING OF CAPITAL GOODS EXPORTS  / MCAP /

MANR(J)    REST OF MANUFACTURING GOODS EXPORTS  / MREST /

S          LABOUR SKILL CATEGORIES  / RURAL         RURAL
                                      URBAN-SKIL    URBAN-SKILLED
                                      URBAN-UNSK    URBAN-UNSKILLED  /


ALIAS (TE,TEP),(T,TP),(T5,TSP),(S,SP),(I,J) ;

$STITLE TRANSACTIONS MATRIX DATA
TABLE TM1980(TM,TM) TRANSACTIONS MATRIX FOR 1980 (BILLIONS OF PESOS)
```

	AGR	MIN	OIL	REF	PETR	MCAP	MREST
AGR	45.070	0.001					241.242
MIN	0.423	21.190	0.544	0.214	0.007	24.534	11.511
OIL				35.704	8.408		
REF	4.438	0.434	0.314	3.261	0.126	1.005	5.639
PETR	0.503	0.002	0.110	1.476	0.037	0.005	15.250
MCAP	6.538	1.813	0.805	0.414	0.024	142.764	26.962
MREST	55.511	1.690	0.415	1.026	0.177	30.454	325.216
CONST							
ELEC	2.441	2.203	0.080	0.477	2.880	7.713	20.452
TRANS	4.545	0.772	2.312	1.524	0.273	13.610	34.175
COM	13.680	2.929	2.433	1.844	0.446	50.927	117.490
SER	4.934	2.576	1.969	2.522	0.733	18.378	36.330
GOV							
IMPORTS	4.192	1.984	3.378	2.934	1.173	86.223	120.733
TOT-INT	142.475	35.594	12.360	51.396	14.284	375.613	955.000
CAPITAL	277.159	37.845	108.694	5.268	0.218	141.017	445.464
LABOUR	94.109	20.599	30.659	8.967	0.451	107.028	207.018
TOT-VA	371.268	58.444	139.353	14.235	0.669	248.045	652.482
IND-TAX	-3.219	3.782	140.439	29.535	4.790	23.389	41.877
TOT-INPT	510.524	97.820	292.152	95.166	19.743	647.047	1649.359

+	CONST	ELEC	TRANS	COM	SER	GOV	TOT-I-D
AGR		0.008			1.736	0.739	288.796
MIN	15.012				0.164	0.025	73.624
OIL		19.325					63.437
REF	7.608	0.556	20.386	2.573	2.904	1.620	50.864
PETR		0.200			0.005		17.588
MCAP	103.818	0.584	16.461	11.279	27.078	2.397	340.937
MREST	90.019	1.278	12.819	38.190	57.238	14.143	628.176
CONST							
ELEC	2.229	3.617	1.028	11.001	5.910	2.732	62.763
TRANS	19.874	0.873	6.179	29.425	14.086	7.035	134.683
COM	35.500	5.197	16.443	26.183	24.825	5.469	303.566
SER	26.485	1.670	18.342	115.601	144.210	274.070	647.820

```
GOV
IMPORTS     20.578   1.340   27.570     2.212     4.463    5.040    281.820
TOT-INT    321.123  34.648  119.228   236.464   282.619  313.270   2894.074
CAPITAL    100.838  19.877  193.432   720.702   490.409    0.422   2516.279
LABOUR     185.108  24.029   99.952   226.467   476.589  134.850   1610.928
TOT-VA     285.946  43.906  293.384   947.169   966.998  135.272   4127.207
IND-TAX      1.218   0.369   -7.783    63.832    14.475    0.202    342.870
TOT-INPT   608.287  78.923  404.829  1247.465  1264.092  448.744   7364.151

+            PRV-CON    GOV-CON    INVEST     EXPORTS    TOT-F-D      TOT-OUT

AGR          170.499                37.874     13.355    221.728      510.524
MIN            0.083                 2.411     21.702     24.196       97.820
OIL                                  1.080    227.635    228.715      292.152
REF           34.094                 1.221      8.987     44.302       95.166
PETR                                -0.726      2.881      2.155       19.743
MCAP         108.374               167.870     29.866    306.110      647.047
MREST        904.173                57.695     59.314   1021.182     1649.358
CONST                              608.287               608.287      608.287
ELEC          13.673                -0.270      2.757     16.160       78.923
TRANS        228.200                20.263     21.683    270.146      404.829
COM          772.981               152.741     32.653    958.375     1247.465
SER          586.870                 2.599     12.328    601.797     1264.092
GOV                     448.744                          448.744      448.744
IMPORTS       89.709               156.536               246.245      528.065
TOT-INT     2908.656    448.744   1207.581    433.161   4998.142     7892.216
CAPITAL                                                              2859.149
LABOUR                                                               1610.928
TOT-VA                                                               4470.077
IND-TAX                                                               342.870
TOT-INPT    2908.656    448.744   1207.581    433.161   4998.142    12362.293;

PARAMETER XJ80(J)        GROSS OUTPUT IN SECTOR J (1980)
          AIJ80(ID,J)    TECHNICAL COEFFICIENTS MATRIX (1980)
          A80(I,J)       INTERMEDIATE INPUT OF GOOD I PER UNIT OF GROSS
                         OUTPUT OF SECTOR J
          NM(I)          NON-COMPETITIVE IMPORT DEMAND PER UNIT OF GROSS
                         OUTPUT OF SECTOR I;

XJ80(J)               = SUM(ICI, TM1980(ICI,J));
AIJ80(ID,J)$XJ80(J)   = TM1980(ID,J) / XJ80(J) ;
A80(I,J)$XJ80(J)      = TM1980(I,J) / XJ80(J)  ;
NM(I)$XJ80(I)         = TM1980("IMPORTS",I) / XJ80(I) ;
DISPLAY XJ80,AIJ80,A80,NM ;

* B MATRIX
* Obtained from Banco de Mexico (1986)
 TABLE    B80(I,J)  CAPITAL SHARE MATRIX FOR 1980 (UNITY)

            AGR         MIN         OIL         REF         PETR        MCAP
AGR         0.414
MIN                     0.05
OIL                                 0.01
REF                                             0.09
PETR                                                        0.07
MCAP        0.121       0.215       0.243       0.158       0.330       0.406
MREST
CONST       0.190       0.285       0.255       0.180       0.15        0.189
ELEC
```

TRANS						
COM	0.112	0.2	0.218	0.2	0.15	0.168
SER						
GOV						

+	MREST	CONST	ELEC	TRANS	COM	SER	GOV
AGR							
MIN							
OIL							
REF							
PETR							
MCAP	0.170	0.369	0.263	0.239	0.176	0.276	0.0
MREST	0.230						
CONST	0.2	0.059	0.365	0.453	0.649	0.422	1.0
ELEC			0.102				
TRANS				0.017			
COM	0.2	0.341	0.156	0.167	0.148		
SER						0.148	
GOV							

```
***** SEE APPENDIX A AND SECTION 6.1 FOR A DESCRIPTION OF THE
      REMAINING DATA BASE EMPLOYED IN THE SOLUTION OF THE
      BASE RUN OF THE MODEL

$STITLE MODEL DEFINITION
* ALL EQUATIONS AND VARIABLES ARE IN 10E9 1980 PESOS
 EQUATIONS

 MB(I,TE)            MATERIAL BALANCE CONSTRAINT
 FEB(TE)             FOREIGN EXCHANGE BALANCE CONSTRAINT
 CD(I,TE)            COBB-DOUGLAS PRODUCTION FUNCTIONS
 LMKT(S,TE)          LABOUR MARKET CONSTRAINT
 DII(I,TE)           DEMAND FOR INTERMEDIATE INPUTS
 DNCI(TE)            DEMAND FOR NON-COMPETITIVE IMPORTS
 CCC(I,TE)           CAPITAL CAPACITY CONSTRAINT
 INVO(TE)            1980 ENDOG DISTRIBUTION OF INVEST BY S. OF DESTINATION
 INVORI(I,TE)        INVESTMENT BY SECTOR OF ORIGIN
 RESER(TE)           OIL AND GAS RESERVES
 EXTR(TE)            EXTRACTION OF OIL AND GAS
 FORDEBT(TE)         ACCUMULATED FOREIGN DEBT
 DEBSER(TE)          DEBT SERVICE
 ELES(TE)            EXTENDED LINEAR EXPENDITURE SYSTEM
 SWF1                SOCIAL WELFARE FUNCTION TO BE MAXIMIZED

 VARIABLES

 MAX                 MAXIMAND: MAXIMIZATION OF THE SWF
 BOR(TE)             NET FOREIGN BORROWING YEAR T

 POSITIVE VARIABLES

 X(I,TE)             GROSS OUTPUT OF SECTOR I  YEAR T
 M(I,TE)             COMPETITIVE IMPORTS OF GOOD I  YEAR T
 INV(I,TE)           INVESTMENT BY SECTOR OF ORIGIN I  YEAR T
 INT(I,TE)           INTERMEDIATE INPUTS OF GOOD I TO OTHER SECTORS YEAR T
 OILEXP(TE)          ENDOGENOUS EXPORTS OF OIL AND GAS  YEAR T
 MCAPEXP(TE)         ENDOG EXPORTS OF MANUFACTURING CAPITAL GOODS  YEAR T
 MRESTEXP(TE)        ENDOG EXPORTS OF MANUF CONSUMP & INTERM GOODS  YEAR T
 NCI(TE)             NON-COMPETITIVE IMPORTS ACROSS SECTORS  YEAR T
```

```
 CAP(I,TE)            CAPITAL STOCK FOR PRODUCTION OF GOOD I  YEAR T
 LD(I,S,TE)           LABOUR BY SKILL CATEGORY S FOR PRODUCTION OF GOOD I
 DK(I,TE)             INVESTMENT BY SECTOR OF DESTINATION I  YEAR T
 EXT(TE)              EXTRACTION OF OIL AND GAS RESERVES  YEAR T
 RES(TE)              OIL AND GAS RESERVES  YEAR T
 DEBT(TE)             ACCUMULATED FOREIGN DEBT  YEAR T
 IP(TE)               INTEREST PAYMENTS ON FOREIGN DEBT YEAR T
 CON(I,TE)            CONSUMPTION DEMAND FOR GOOD I  YEAR T
 UTI(TE)              UTILITY OF AGGREGATE CONSUMPTION  YEAR T  ;

$EJECT
$DOUBLE
 MB(I,T)..      X(I,T) + M(I,T)$IM(I)   =G=   INT(I,T) + CON(I,T) +
                GOVEX(I,T) + INV(I,T) + EXP(I,T) + OILEXP(T)$HYD(I) +
                MCAPEXP(T)$MANC(I) + MRESTEXP(T)$MANR(I) ;

 FEB(T)..       SUM(I, PM(I,T)*M(I,T)) + NCI(T) + DEBT(T)  =E=
                SUM(I, PE(I,T)*EXP(I,T)) + PE("OIL",T)*OILEXP(T) +
                PE("MCAP",T)*MCAPEXP(T) + PE("MREST",T)*MRESTEXP(T) +
                BOR(T) ;

 DII(I,T)..             INT(I,T)        =E=   SUM(J, A80(I,J) * X(J,T)) ;

 DNCI(T)..              NCI(T)          =E=   SUM(I, NM(I)*X(I,T)  +
                                              NMC(I)*DK(I,T)) ;

 CD(I,T)..         X(I,T)  =E=  A(I) * PROD(S, LD(I,S,T)** ALPHL(I,S)) *
                   CAP(I,T)**(1 - SUM(S, ALPHL(I,S))) ;

 LMKT(S,T)..       SUM(I, LD(I,S,T))  =L=  LS(S,T) ;

 CCC(I,TE)$(ORD(TE) GT 1).. CAP(I,TE) =E= K80(I)*((1-D(I))**
                              (INTERVAL*BET(TE))) +
                GL(I)*SUM(TEP$(ORD(TEP) LT ORD(TE)),    DK(I,TEP)*
                ((1-D(I))**(INTERVAL*(ORD(TE)-ORD(TEP))))) ;

 INVO("1980")..          INV80          =E=   SUM(I, DK(I,"1980")) ;

 INVORI(I,T)..           INV(I,T)       =E=   SUM(J, B80(I,J)*DK(J,T)) ;

 RESER(TE+1)$(ORD(TE) GT 2)..            RES(TE+1)   =E=   RES(TE) -
                                         (INTERVAL*EXT(TE)) ;

 EXTR(T)..             EXT(T)       =E=   Q*X("OIL",T) ;

 FORDEBT(TE)$(ORD(TE) GT 1)..   DEBT(TE)      =E=    DEBT("1980") +
                                SUM(TEP$TS(TE,TEP), BOR(TEP)) ;

 DEBSER(T)..                    IP(T)     =E=    R*DEBT(T) ;

 ELES(T)..            UTI(T)   =E=   DELTA(T)*POP(T)*SUM(I$IC(I),
                      MES(I) * (LOG(CON(I,T) / POP(T)) - LOG(MINCON(I)))) ;

 SWF1..        MAX   =E=  1000*SUM(T, DELTA(T)*SUM(I$IC(I), CON(I,T)) +
                          SUM(I, PK(i,"2008")*CAP(I,"2008")) +
                          QR*RES("2008") - DEBT("2008") ;

 $SINGLE
 $STITLE MODEL DEFINITIONS AND BOUNDS
```

```
*LOWER BOUNDS

 CON.LO(I,T)$IC(I)   = 0.01 ;
 EXT.LO(T)           = 0.01 ;
 X.LO(I,T)           = 0.01 ;
 CAP.LO(I,TE)        = 0.01 ;
 LD.LO(I,S,T)        = 0.08 * LD.L(I,S,T) ;

*INITIAL CONDITIONS

 CAP.L(I,T)          =   K80(I) ;
 CON.L(I,T)$IC(I)    =   TM1980("PRV-CON",I) ;
 EXT.UP(T)           =   MAXEXT(T) ;
 RES.FX("1984")      =   RES84 ;
 RES.FX("1988")      =   RES88 ;
 LD.L(I,S,T)         =   XLE(I,S) ;
 X.L(I,T)            =   A(I) * PROD(S, LD.L(I,S,T)**ALPHL(I,S)) *
                         CAP.L(I,T)**(1 - SUM(S, ALPHL(I,S))) ;
 DEBT.FX("1980")     =   DEBT80 ;
 BOR.FX("1984")      =   BOR84 ;

 MODEL MEXNL NON LINEAR FORMULATION /
 MB, FEB, LMKT, DTI, DNCI, CCC, INVO, INVORI,
 RESER, EXTR, FORDEBT, DEBSER, ELES, CO, SWF1 /

 OPTION LIMROW  = 54, LIMCOL = 54 ;
 OPTION ITERLIM = 10000 ;

 SOLVE MEXNL MAXIMIZING MAX USING NLP ;
```

```
MODEL STATISTICS      SOLVE MEXNLT USING NLP FROM LINE 795

MODEL STATISTICS

BLOCKS OF EQUATIONS     18        SINGLE EQUATIONS    742
BLOCKS OF VARIABLES     21        SINGLE VARIABLES    919
NON ZERO ELEMENTS     3872        NON LINEAR N-Z      903
DERIVATIVE POOL         72        CONSTANT POOL       100
CODE LENGTH          12293

GENERATION TIME        =        23.210 SECONDS


EXECUTION TIME         =        27.810 SECONDS

               S O L V E      S U M M A R Y

     MODEL   MEXNLT                    OBJECTIVE  MAX
     TYPE    NLP                       DIRECTION  MAXIMIZE
     SOLVER  MINOS5                    FROM LINE  795

**** SOLVER STATUS       1 NORMAL COMPLETION
**** MODEL STATUS        2 LOCALLY OPTIMAL
**** OBJECTIVE VALUE             252580.1724

 RESOURCE USAGE, LIMIT        1533.257      2000.000
 ITERATION COUNT, LIMIT       4688          10000
 EVALUATION ERRORS               0              0

     M I N O S  ---  VERSION  5.0   APR  1984
     = = = = =
     COURTESY OF B. A. MURTAGH AND M. A. SAUNDERS,
                 DEPARTMENT OF OPERATIONS RESEARCH,
                 STANFORD UNIVERSITY,
                 STANFORD   CALIFORNIA   94305   U.S.A.


 WORK SPACE NEEDED (ESTIMATE)  --    64783 WORDS.
 WORK SPACE AVAILABLE          --    80692 WORDS.
 (MAXIMUM OBTAINABLE           --   282222 WORDS.)

 EXIT -- OPTIMAL SOLUTION FOUND
 MAJOR ITERATIONS          121
 NORM RG / NORM PI   2.444E-07
 TOTAL USED            1534.62 UNITS
 MINOSS TIME           1527.01 (INTERPRETER -      628.48)

---- EQU MB          MATERIAL BALANCE CONSTRAINT
```

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	14.4680	14.4680	+INF	-27.3729
AGR .1988	15.6250	15.6250	+INF	-19.1680
AGR .1992	16.8750	16.8750	+INF	-11.4881
AGR .1996	18.2260	18.2260	+INF	-7.0891
AGR .2000	19.6840	19.6840	+INF	-3.8880
AGR .2004	21.2580	21.2580	+INF	-2.5772
MIN .1984	23.4550	23.4550	+INF	-11.7445
MIN .1988	25.3310	25.3310	+INF	-6.8400
MIN .1992	27.3580	27.3580	+INF	-4.1050
MIN .1996	29.5470	29.5470	+INF	-2.3379
MIN .2000	31.9100	31.9100	+INF	-1.3125

MIN .2004	34.4630	34.4630	+INF	-0.9319
OIL .1984	.	.	+INF	-21.5866
OIL .1988	.	.	+INF	-9.8010
OIL .1992	.	.	+INF	-5.9235
OIL .1996	.	.	+INF	-3.5903
OIL .2000	.	.	+INF	-2.1134
OIL .2004	.	.	+INF	-1.4696
REF .1984	9.7330	9.7330	+INF	-14.4785
REF .1988	10.5120	10.5120	+INF	-8.2842
REF .1992	11.3530	11.3530	+INF	-4.9258
REF .1996	12.2610	12.2610	+INF	-2.8250
REF .2000	13.2420	13.2420	+INF	-1.6598
REF .2004	14.3010	14.3010	+INF	-1.0775
PETR .1984	3.3380	3.3380	+INF	-13.8195
PETR .1988	3.6050	3.6050	+INF	-7.9477
PETR .1992	3.8930	3.8930	+INF	-4.7509
PETR .1996	4.2050	4.2050	+INF	-2.6662
PETR .2000	4.5410	4.5410	+INF	-1.5460
PETR .2004	4.9050	4.9050	+INF	-1.0153
MCAP .1984	.	.	+INF	-22.4626
MCAP .1988	.	.	+INF	-15.0645
MCAP .1992	.	.	+INF	-8.4304
MCAP .1996	.	.	+INF	-4.7923
MCAP .2000	.	.	+INF	-2.6691
MCAP .2004	.	.	+INF	-1.8591
MREST.1984	.	.	+INF	-23.9064
MREST.1988	.	.	+INF	-15.9008
MREST.1992	.	.	+INF	-9.1875
MREST.1996	.	.	+INF	-5.2967
MREST.2000	.	.	+INF	-3.0160
MREST.2004	.	.	+INF	-2.0156
CONST.1984	.	.	+INF	-21.4450
CONST.1988	.	.	+INF	-12.9313
CONST.1992	.	.	+INF	-5.6270
CONST.1996	.	.	+INF	-3.3861
CONST.2000	.	.	+INF	-1.9517
CONST.2004	.	.	+INF	-1.3198
ELEC .1984	.	.	+INF	-26.7032
ELEC .1988	.	.	+INF	-16.6794
ELEC .1992	.	.	+INF	-9.1781
ELEC .1996	.	.	+INF	-5.0612
ELEC .2000	.	.	+INF	-2.6375
ELEC .2004	.	.	+INF	-1.6301
TRANS.1984	23.4180	23.4180	+INF	-15.5861
TRANS.1988	25.2910	25.2910	+INF	-9.8985
TRANS.1992	27.3150	27.3150	+INF	-5.9477
TRANS.1996	29.4500	29.4500	+INF	-3.2732
TRANS.2000	31.8600	31.8600	+INF	-1.7436
TRANS.2004	34.4090	34.4090	+INF	-1.0205
COM .1984	35.3060	35.3060	+INF	-19.0988
COM .1988	38.1300	38.1300	+INF	-14.1614
COM .1992	41.1810	41.1810	+INF	-6.8443
COM .1996	44.4750	44.4750	+INF	-3.6062
COM .2000	48.0330	48.0330	+INF	-1.8249
COM .2004	51.8760	51.8760	+INF	-1.0830
SER .1984	.	.	+INF	-20.2137
SER .1988	.	.	+INF	-15.3799
SER .1992	.	.	+INF	-7.7046
SER .1996	.	.	+INF	-3.9710
SER .2000	.	.	+INF	-1.9566
SER .2004	.	.	+INF	-1.2262
GOV .1984	484.6440	484.6440	+INF	-18.1555
GOV .1988	523.4160	523.4160	+INF	-12.1058
GOV .1992	565.2900	565.2900	+INF	-6.7723
GOV .1996	610.5140	610.5140	+INF	-3.6855
GOV .2000	659.3550	659.3550	+INF	-2.0085
GOV .2004	712.1050	712.1050	+INF	-1.1144

---- EQU FEB FOREIGN EXCHANGE BALANCE CONSTRAINT

	LOWER	LEVEL	UPPER	MARGINAL
1984	158.5660	158.5660	158.5660	23.4229
1988	158.0290	158.0290	158.0290	18.0630
1992	174.4870	174.4870	174.4870	10.1084
1996	184.6760	184.6760	184.6760	5.6728
2000	198.1180	198.1180	198.1180	3.0921
2004	212.3750	212.3750	212.3750	1.9909

---- EQU CD COBB-DOUGLAS PRODUCTION FUNCTIONS

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	.	.	.	20.7603
AGR .1988	.	.	.	14.1797
AGR .1992	.	.	.	10.2275
AGR .1996	.	.	.	6.8796
AGR .2000	.	.	.	5.6879
AGR .2004	.	.	.	4.3333
MIN .1984	.	.	.	6.0029
MIN .1988	.	.	.	2.9684
MIN .1992	.	.	.	2.3387
MIN .1996	.	.	.	1.4562
MIN .2000	.	.	.	0.8724
MIN .2004	.	.	.	0.8896
OIL .1984	.	.	.	9.0185
OIL .1988	.	.	.	5.1247
OIL .1992	.	.	.	3.6882
OIL .1996	.	.	.	2.1914
OIL .2000	.	.	.	1.3001
OIL .2004	.	.	.	1.2777
REF .1984	.	.	.	3.4904
REF .1988	.	.	.	2.6471
REF .1992	.	.	.	1.6433
REF .1996	.	.	.	0.9333
REF .2000	.	.	.	0.5719
REF .2004	.	.	.	0.4106
PETR .1984	.	.	.	16.2157
PETR .1988	.	.	.	8.6440
PETR .1992	.	.	.	1.7487
PETR .1996	.	.	.	1.0351
PETR .2000	.	.	.	0.5964
PETR .2004	.	.	.	0.4306
MCAP .1984	.	.	.	10.0688
MCAP .1988	.	.	.	6.7348
MCAP .1992	.	.	.	3.7874
MCAP .1996	.	.	.	2.1977
MCAP .2000	.	.	.	1.2153
MCAP .2004	.	.	.	1.0972
MREST.1984	.	.	.	10.5160
MREST.1988	.	.	.	6.3431
MREST.1992	.	.	.	4.2114
MREST.1996	.	.	.	2.5543
MREST.2000	.	.	.	1.6398
MREST.2004	.	.	.	1.4040
CONST.1984	.	.	.	9.9082
CONST.1988	.	.	.	5.0496
CONST.1992	.	.	.	2.1065
CONST.1996	.	.	.	1.9733
CONST.2000	.	.	.	1.6185
CONST.2004	.	.	.	0.9062
ELEC .1984	.	.	.	17.2802

ELEC .1988	.	.	.	11.0779
ELEC .1992	.	.	.	6.7419
ELEC .1996	.	.	.	3.9154
ELEC .2000	.	.	.	2.3350
ELEC .2004	.	.	.	1.7774
TRANS.1984	.	.	.	9.5942
TRANS.1988	.	.	.	5.4343
TRANS.1992	.	.	.	3.9686
TRANS.1996	.	.	.	2.3879
TRANS.2000	.	.	.	1.4396
TRANS.2004	.	.	.	1.1302
COM .1984	.	.	.	15.2153
COM .1988	.	.	.	8.9113
COM .1992	.	.	.	5.6926
COM .1996	.	.	.	3.5686
COM .2000	.	.	.	2.1419
COM .2004	.	.	.	1.3989
SER .1984	.	.	.	15.5153
SER .1988	.	.	.	9.5203
SER .1992	.	.	.	6.1315
SER .1996	.	.	.	3.6143
SER .2000	.	.	.	2.0823
SER .2004	.	.	.	1.6645
GOV .1984	.	.	.	3.9358
GOV .1988	.	.	.	2.8120
GOV .1992	.	.	.	1.6909
GOV .1996	.	.	.	1.0086
GOV .2000	.	.	.	0.5957
GOV .2004	.	.	.	0.4611

---- EQU DII DEMAND FOR INTERMEDIATE INPUTS

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	.	.	.	-27.3729
AGR .1988	.	.	.	-19.1680
AGR .1992	.	.	.	-11.4881
AGR .1996	.	.	.	-7.0891
AGR .2000	.	.	.	-3.8880
AGR .2004	.	.	.	-2.5772
MIN .1984	.	.	.	-11.7445
MIN .1988	.	.	.	-6.8400
MIN .1992	.	.	.	-4.1050
MIN .1996	.	.	.	-2.3379
MIN .2000	.	.	.	-1.3125
MIN .2004	.	.	.	-0.9319
OIL .1984	.	.	.	-21.5866
OIL .1988	.	.	.	-9.8010
OIL .1992	.	.	.	-5.9235
OIL .1996	.	.	.	-3.5903
OIL .2000	.	.	.	-2.1134
OIL .2004	.	.	.	-1.4696
REF .1984	.	.	.	-14.4785
REF .1988	.	.	.	-8.2842
REF .1992	.	.	.	-4.9258
REF .1996	.	.	.	-2.8250
REF .2000	.	.	.	-1.6598
REF .2004	.	.	.	-1.0775
PETR .1984	.	.	.	-13.8195
PETR .1988	.	.	.	-7.9477
PETR .1992	.	.	.	-4.7509
PETR .1996	.	.	.	-2.6662
PETR .2000	.	.	.	-1.5460
PETR .2004	.	.	.	-1.0153
MCAP .1984	.	.	.	-22.4626
MCAP .1988	.	.	.	-15.0645

MCAP .1992	.	.	.	-8.4304
MCAP .1996	.	.	.	-4.7923
MCAP .2000	.	.	.	-2.6691
MCAP .2004	.	.	.	-1.8591
MREST.1984	.	.	.	-23.9064
MREST.1988	.	.	.	-15.9008
MREST.1992	.	.	.	-9.1875
MREST.1996	.	.	.	-5.2967
MREST.2000	.	.	.	-3.0160
MREST.2004	.	.	.	-2.0156
CONST.1984	.	.	.	-21.4450
CONST.1988	.	.	.	-12.9313
CONST.1992	.	.	.	-5.6270
CONST.1996	.	.	.	-3.3861
CONST.2000	.	.	.	-1.9517
CONST.2004	.	.	.	-1.3198
ELEC .1984	.	.	.	-26.7032
ELEC .1988	.	.	.	-16.6794
ELEC .1992	.	.	.	-9.1781
ELEC .1996	.	.	.	-5.0612
ELEC .2000	.	.	.	-2.6375
ELEC .2004	.	.	.	-1.6301
TRANS.1984	.	.	.	-15.5861
TRANS.1988	.	.	.	-9.8985
TRANS.1992	.	.	.	-5.9477
TRANS.1996	.	.	.	-3.2732
TRANS.2000	.	.	.	-1.7436
TRANS.2004	.	.	.	-1.0205
COM .1984	.	.	.	-19.0988
COM .1988	.	.	.	-14.1614
COM .1992	.	.	.	-6.8443
COM .1996	.	.	.	-3.6062
COM .2000	.	.	.	-1.8249
COM .2004	.	.	.	-1.0830
SER .1984	.	.	.	-20.2137
SER .1988	.	.	.	-15.3799
SER .1992	.	.	.	-7.7046
SER .1996	.	.	.	-3.9710
SER .2000	.	.	.	-1.9566
SER .2004	.	.	.	-1.2262
GOV .1984	.	.	.	-18.1555
GOV .1988	.	.	.	-12.1058
GOV .1992	.	.	.	-6.7723
GOV .1996	.	.	.	-3.6855
GOV .2000	.	.	.	-2.0085
GOV .2004	.	.	.	-1.1144

---- EQU DNCI DEMAND FOR NON-COMPETITIVE IMPORTS

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	.	.	-23.4229
1988	.	.	.	-18.0630
1992	.	.	.	-10.1084
1996	.	.	.	-5.6728
2000	.	.	.	-3.0921
2004	.	.	.	-1.9909

---- EQU LMKT LABOUR MARKET CONSTRAINT

	LOWER	LEVEL	UPPER	MARGINAL
RURAL .1984	-INF	8444.0000	8444.0000	1.2020
RURAL .1988	-INF	9727.0000	9727.0000	0.7764
RURAL .1992	-INF	11205.0000	11205.0000	0.4640
RURAL .1996	-INF	12908.0000	12908.0000	0.2622

RURAL .2000	-INF	14869.0000	14869.0000	0.1512
RURAL .2004	-INF	17129.0000	17129.0000	0.1113
URBAN-SKIL.1984	-INF	10110.0000	10110.0000	4.0935
URBAN-SKIL.1988	-INF	11557.0000	11557.0000	2.8952
URBAN-SKIL.1992	-INF	13211.0000	13211.0000	1.5071
URBAN-SKIL.1996	-INF	15101.0000	15101.0000	0.8100
URBAN-SKIL.2000	-INF	17262.0000	17262.0000	0.4325
URBAN-SKIL.2004	-INF	19732.0000	19732.0000	0.3096
URBAN-UNSK.1984	-INF	6840.0000	6840.0000	2.0454
URBAN-UNSK.1988	-INF	7940.0000	7940.0000	1.2624
URBAN-UNSK.1992	-INF	9217.0000	9217.0000	0.7575
URBAN-UNSK.1996	-INF	10700.0000	10700.0000	0.4300
URBAN-UNSK.2000	-INF	12422.0000	12422.0000	0.2363
URBAN-UNSK.2004	-INF	14421.0000	14421.0000	0.1692

---- EQU CCC CAPITAL CAPACITY CONSTRAINT

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	941.7822	941.7822	941.7822	7.3494
AGR .1988	868.6699	868.6699	868.6699	5.1078
AGR .1992	801.2334	801.2334	801.2334	3.6703
AGR .1996	739.0322	739.0322	739.0322	2.4991
AGR .2000	681.6598	681.6598	681.6598	2.1500
AGR .2004	628.7413	628.7413	628.7413	1.7322
AGR .2008	579.9309	579.9309	579.9309	EPS
MIN .1984	64.9495	64.9495	64.9495	4.8964
MIN .1988	57.4993	57.4993	57.4993	2.5252
MIN .1992	50.9037	50.9037	50.9037	1.9371
MIN .1996	45.0647	45.0647	45.0647	1.1979
MIN .2000	39.8955	39.8955	39.8955	0.7618
MIN .2004	35.3192	35.3192	35.3192	0.7303
MIN .2008	31.2678	31.2678	31.2678	EPS
OIL .1984	509.5209	509.5209	509.5209	4.2324
OIL .1988	451.0752	451.0752	451.0752	2.2737
OIL .1992	399.3336	399.3336	399.3336	1.7842
OIL .1996	353.5272	353.5272	353.5272	1.0884
OIL .2000	312.9751	312.9751	312.9751	0.7140
OIL .2004	277.0746	277.0746	277.0746	0.6639
OIL .2008	245.2921	245.2921	245.2921	EPS
REF .1984	108.8448	108.8448	108.8448	2.5031
REF .1988	100.3950	100.3950	100.3950	2.2109
REF .1992	92.6012	92.6012	92.6012	1.7986
REF .1996	85.4124	85.4124	85.4124	1.1087
REF .2000	78.7816	78.7816	78.7816	0.8496
REF .2004	72.6657	72.6657	72.6657	0.6153
REF .2008	67.0245	67.0245	67.0245	EPS
PETR .1984	16.1161	16.1161	16.1161	2.8465
PETR .1988	14.8650	14.8650	14.8650	1.6253
PETR .1992	13.7110	13.7110	13.7110	1.3424
PETR .1996	12.6466	12.6466	12.6466	0.9566
PETR .2000	11.6648	11.6648	11.6648	0.6370
PETR .2004	10.7593	10.7593	10.7593	0.4703
PETR .2008	9.9240	9.9240	9.9240	EPS
MCAP .1984	624.3804	624.3804	624.3804	6.2672
MCAP .1988	552.7595	552.7595	552.7595	4.0976
MCAP .1992	489.3540	489.3540	489.3540	2.4040
MCAP .1996	433.2216	433.2216	433.2216	1.4690
MCAP .2000	383.5279	383.5279	383.5279	0.8283
MCAP .2004	339.5345	339.5345	339.5345	0.8925
MCAP .2008	300.5875	300.5875	300.5875	EPS
MREST.1984	1591.5796	1591.5796	1591.5796	6.1938
MREST.1988	1409.0140	1409.0140	1409.0140	3.5453
MREST.1992	1247.3899	1247.3899	1247.3899	2.5844
MREST.1996	1104.3054	1104.3054	1104.3054	1.6515
MREST.2000	977.6336	977.6336	977.6336	1.1499

MREST.2004	865.4920	865.4920	865.4920	1.0707
MREST.2008	766.2138	766.2138	766.2138	EPS
CONST.1984	67.1640	67.1640	67.1640	25.4991
CONST.1988	57.0455	57.0455	57.0455	8.6761
CONST.1992	48.4514	48.4514	48.4514	4.6149
CONST.1996	41.1521	41.1521	41.1521	2.2038
CONST.2000	34.9524	34.9524	34.9524	1.7200
CONST.2004	29.6867	29.6867	29.6867	0.8831
CONST.2008	25.2143	25.2143	25.2143	EPS
ELEC .1984	350.1491	350.1491	350.1491	3.4045
ELEC .1988	322.9663	322.9663	322.9663	1.9997
ELEC .1992	297.8939	297.8939	297.8939	1.4276
ELEC .1996	274.7678	274.7678	274.7678	0.8996
ELEC .2000	253.4371	253.4371	253.4371	0.6074
ELEC .2004	233.7623	233.7623	233.7623	0.4998
ELEC .2008	215.6149	215.6149	215.6149	EPS
TRANS.1984	339.7953	339.7953	339.7953	5.9111
TRANS.1988	313.4163	313.4163	313.4163	3.2326
TRANS.1992	289.0852	289.0852	289.0852	2.3290
TRANS.1996	266.6430	266.6430	266.6430	1.4790
TRANS.2000	245.9430	245.9430	245.9430	0.9444
TRANS.2004	226.8500	226.8500	226.8500	0.7782
TRANS.2008	209.2392	209.2392	209.2392	EPS
COM .1984	1369.4210	1369.4210	1369.4210	9.7882
COM .1988	1212.3386	1212.3386	1212.3386	5.5838
COM .1992	1073.2746	1073.2746	1073.2746	3.6791
COM .1996	950.1623	950.1623	950.1623	2.3897
COM .2000	841.1719	841.1719	841.1719	1.4754
COM .2004	744.6834	744.6834	744.6834	0.9363
COM .2008	659.2629	659.2629	659.2629	EPS
SER .1984	1387.6735	1387.6735	1387.6735	9.3241
SER .1988	1228.4974	1228.4974	1228.4974	5.3276
SER .1992	1087.5799	1087.5799	1087.5799	3.9603
SER .1996	962.8267	962.8267	962.8267	2.4916
SER .2000	852.3835	852.3835	852.3835	1.5130
SER .2004	754.6090	754.6090	754.6090	1.3471
SER .2008	668.0499	668.0499	668.0499	EPS
GOV .1984	1018.6489	1018.6489	1018.6489	0.9491
GOV .1988	1018.6489	1018.6489	1018.6489	0.7321
GOV .1992	1018.6489	1018.6489	1018.6489	0.4753
GOV .1996	1018.6489	1018.6489	1018.6489	0.3061
GOV .2000	1018.6489	1018.6489	1018.6489	0.1952
GOV .2004	1018.6489	1018.6489	1018.6489	0.1631
GOV .2008	1018.6489	1018.6489	1018.6489	EPS

---- EQU INVO 1980 ENDOG DISTRIBUTION OF INVEST BY S. OF DESTINATION

	LOWER	LEVEL	UPPER	MARGINAL
1980	-1202.8000	-1202.8000	-1202.8000	-36.6310

---- EQU INVORI INVESTMENT BY SECTOR OF ORIGIN

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	.	.	.	-27.3729
AGR .1988	.	.	.	-19.1680
AGR .1992	.	.	.	-11.4881
AGR .1996	.	.	.	-7.0891
AGR .2000	.	.	.	-3.8880
AGR .2004	.	.	.	-2.5772
MIN .1984	.	.	.	-11.7445
MIN .1988	.	.	.	-6.8400
MIN .1992	.	.	.	-4.1050
MIN .1996	.	.	.	-2.3379
MIN .2000	.	.	.	-1.3125

MIN .2004	.	.	.	-0.9319
OIL .1984	.	.	.	-21.5866
OIL .1988	.	.	.	-9.8010
OIL .1992	.	.	.	-5.9235
OIL .1996	.	.	.	-3.5903
OIL .2000	.	.	.	-2.1134
OIL .2004	.	.	.	-1.4696
REF .1984	.	.	.	-14.4785
REF .1988	.	.	.	-8.7842
REF .1992	.	.	.	-4.9258
REF .1996	.	.	.	-2.8250
REF .2000	.	.	.	-1.6598
REF .2004	.	.	.	-1.0775
PETR .1984	.	.	.	-13.8195
PETR .1988	.	.	.	-7.9477
PETR .1992	.	.	.	-4.7509
PETR .1996	.	.	.	-2.6662
PETR .2000	.	.	.	-1.5460
PETR .2004	.	.	.	-1.0153
MCAP .1984	.	.	.	-22.4626
MCAP .1988	.	.	.	-15.0645
MCAP .1992	.	.	.	-8.4304
MCAP .1996	.	.	.	-4.7923
MCAP .2000	.	.	.	-2.6691
MCAP .2004	.	.	.	-1.8591
MREST.1984	.	.	.	-23.9064
MREST.1988	.	.	.	-15.9008
MREST.1992	.	.	.	-9.1875
MREST.1996	.	.	.	-5.2967
MREST.2000	.	.	.	-3.0160
MREST.2004	.	.	.	-2.0156
CONST.1984	.	.	.	-21.4450
CONST.1988	.	.	.	-12.9313
CONST.1992	.	.	.	-5.6270
CONST.1996	.	.	.	-3.3861
CONST.2000	.	.	.	-1.9517
CONST.2004	.	.	.	-1.3198
ELEC .1984	.	.	.	-26.7032
ELEC .1988	.	.	.	-16.6794
ELEC .1992	.	.	.	-9.1781
ELEC .1996	.	.	.	-5.0612
ELEC .2000	.	.	.	-2.6375
ELEC .2004	.	.	.	-1.6301
TRANS.1984	.	.	.	-15.5861
TRANS.1988	.	.	.	-9.8985
TRANS.1992	.	.	.	-5.9477
TRANS.1996	.	.	.	-3.2732
TRANS.2000	.	.	.	-1.7436
TRANS.2004	.	.	.	-1.0205
COM .1984	.	.	.	-19.0988
COM .1988	.	.	.	-14.1614
COM .1992	.	.	.	-6.8443
COM .1996	.	.	.	-3.6062
COM .2000	.	.	.	-1.8249
COM .2004	.	.	.	-1.0830
SER .1984	.	.	.	-20.2137
SER .1988	.	.	.	-15.3799
SER .1992	.	.	.	-7.7046
SER .1996	.	.	.	-3.9710
SER .2000	.	.	.	-1.9566
SER .2004	.	.	.	-1.2262
GOV .1984	.	.	.	-18.1555
GOV .1988	.	.	.	-12.1058
GOV .1992	.	.	.	-7.7723
GOV .1996	.	.	.	-3.6855
GOV .2000	.	.	.	-2.0085
GOV .2004	.	.	.	-1.1144

```
---- EQU RESER        OIL AND GAS RESERVES

              LOWER          LEVEL          UPPER        MARGINAL

1992            .              .              .             EPS
1996            .              .              .             EPS
2000            .              .              .             EPS
2004            .              .              .             EPS
2008            .              .              .             EPS

---- EQU EXTR         EXTRACTION OF OIL AND GAS

              LOWER          LEVEL          UPPER        MARGINAL

1984            .              .              .           -3.3003
1988            .              .              .           -1.1604
1992            .              .              .           -0.5331
1996            .              .              .           -0.3373
2000            .              .              .           -0.1963
2004            .              .              .           -0.1410

---- EQU FORDEBT      ACCUMULATED FOREIGN DEBT

              LOWER          LEVEL          UPPER        MARGINAL

1984            .              .              .          -23.4229
1988            .              .              .          -18.0630
1992            .              .              .          -10.1084
1996            .              .              .           -5.6728
2000            .              .              .           -3.0921
2004            .              .              .           -1.9909
2008            .              .              .           -1.0517

---- EQU DEBSER       DEBT SERVICE

              LOWER          LEVEL          UPPER        MARGINAL

1984            .              .              .             EPS
1988            .              .              .             EPS
1992            .              .              .             EPS
1996            .              .              .             EPS
2000            .              .              .             EPS
2004            .              .              .             EPS

---- EQU ELES         EXTENDED LINEAR EXPENDITURE SYSTEM

              LOWER          LEVEL          UPPER        MARGINAL

1984        -96.8762       -96.8762       -96.8762          EPS
1988        -71.8309       -71.8309       -71.8309          EPS
1992        -57.1984       -57.1984       -57.1984          EPS
1996        -42.0680       -42.0680       -42.0680          EPS
2000        -30.8480       -30.8480       -30.8480          EPS
2004        -22.5221       -22.5221       -22.5221          EPS

                             LOWER          LEVEL          UPPER          MARGINA

---- EQU SWF1          -321343.4773   -321343.4773   -321343.4773          1.000
  SWF1         SOCIAL WELFARE FUNCTION TO BE MAXIMIZED
```

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR MAX	-INF	252580.1724	+INF	.

MAX MAXIMAND: MAXIMIZATION OF THE SWF

---- VAR X GROSS OUTPUT OF SECTOR I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	0.0100	654.9393	+INF	.
AGR .1988	0.0100	684.6080	+INF	.
AGR .1992	0.0100	692.1323	+INF	.
AGR .1996	0.0100	717.7352	+INF	.
AGR .2000	0.0100	733.4088	+INF	.
AGR .2004	0.0100	746.9080	+INF	.
MIN .1984	0.0100	120.9430	+INF	.
MIN .1988	0.0100	186.2407	+INF	.
MIN .1992	0.0100	208.1453	+INF	.
MIN .1996	0.0100	224.4258	+INF	.
MIN .2000	0.0100	238.6362	+INF	.
MIN .2004	0.0100	260.8139	+INF	.
OIL .1984	0.0100	391.6552	+INF	.
OIL .1988	0.0100	353.1926	+INF	.
OIL .1992	0.0100	392.4987	+INF	.
OIL .1996	0.0100	436.2190	+INF	.
OIL .2000	0.0100	471.1109	+INF	.
OIL .2004	0.0100	499.3674	+INF	.
REF .1984	0.0100	118.1133	+INF	.
REF .1988	0.0100	156.8695	+INF	.
REF .1992	0.0100	224.6799	+INF	.
REF .1996	0.0100	270.4190	+INF	.
REF .2000	0.0100	308.3680	+INF	.
REF .2004	0.0100	354.3825	+INF	.
PETR .1984	0.0100	28.6258	+INF	.
PETR .1988	0.0100	31.1857	+INF	.
PETR .1992	0.0100	34.6021	+INF	.
PETR .1996	0.0100	38.2971	+INF	.
PETR .2000	0.0100	38.5277	+INF	.
PETR .2004	0.0100	40.5946	+INF	.
MCAP .1984	0.0100	952.2592	+INF	.
MCAP .1988	0.0100	1421.4025	+INF	.
MCAP .1992	0.0100	2060.1243	+INF	.
MCAP .1996	0.0100	2295.0599	+INF	.
MCAP .2000	0.0100	2450.1147	+INF	.
MCAP .2004	0.0100	2620.2240	+INF	.
MREST.1984	0.0100	1994.4849	+INF	.
MREST.1988	0.0100	2316.1618	+INF	.
MREST.1992	0.0100	2624.1354	+INF	.
MREST.1996	0.0100	3246.1923	+INF	.
MREST.2000	0.0100	3975.6017	+INF	.
MREST.2004	0.0100	4226.6826	+INF	.
CONST.1984	0.0100	691.9178	+INF	.
CONST.1988	0.0100	613.4610	+INF	.
CONST.1992	0.0100	625.6064	+INF	.
CONST.1996	0.0100	643.8816	+INF	.
CONST.2000	0.0100	650.9998	+INF	.
CONST.2004	0.0100	721.1973	+INF	.
ELEC .1984	0.0100	169.4224	+INF	.
ELEC .1988	0.0100	213.6242	+INF	.
ELEC .1992	0.0100	237.0214	+INF	.
ELEC .1996	0.0100	258.7319	+INF	.
ELEC .2000	0.0100	270.2388	+INF	.

ELEC .2004	0.0100	279.3237	+INF	.
TRANS.1984	0.0100	578.6337	+INF	.
TRANS.1988	0.0100	707.7959	+INF	.
TRANS.1992	0.0100	792.2708	+INF	.
TRANS.1996	0.0100	903.6857	+INF	.
TRANS.2000	0.0100	953.0437	+INF	.
TRANS.2004	0.0100	1013.7628	+INF	.
COM .1984	0.0100	1929.6772	+INF	.
COM .1988	0.0100	2189.7481	+INF	.
COM .1992	0.0100	2490.0018	+INF	.
COM .1996	0.0100	2566.4638	+INF	.
COM .2000	0.0100	2655.8505	+INF	.
COM .2004	0.0100	2685.7370	+INF	.
SER .1984	0.0100	1639.5502	+INF	.
SER .1988	0.0100	1904.0317	+INF	.
SER .1992	0.0100	2222.9985	+INF	.
SER .1996	0.0100	2312.0450	+INF	.
SER .2000	0.0100	2412.9679	+INF	.
SER .2004	0.0100	2424.9268	+INF	.
GOV .1984	0.0100	484.6440	+INF	.
GOV .1988	0.0100	523.4160	+INF	.
GOV .1992	0.0100	565.2900	+INF	.
GOV .1996	0.0100	610.5140	+INF	.
GOV .2000	0.0100	659.3550	+INF	.
GOV .2004	0.0100	712.1050	+INF	.

---- VAR M COMPETITIVE IMPORTS OF GOOD I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	.	.	+INF	-0.3014
AGR .1988	.	61.5527	+INF	.
AGR .1992	.	95.3272	+INF	.
AGR .1996	.	126.9775	+INF	.
AGR .2000	.	150.7229	+INF	.
AGR .2004	.	173.0270	+INF	.
MIN .1984	.	.	+INF	-13.9552
MIN .1988	.	.	+INF	-13.7475
MIN .1992	.	.	+INF	-7.1301
MIN .1996	.	.	+INF	-4.0304
MIN .2000	.	.	+INF	-2.2018
MIN .2004	.	.	+INF	-1.7269
REF .1984	.	.	+INF	-21.7615
REF .1988	.	.	+INF	-12.3914
REF .1992	.	.	+INF	-6.8546
REF .1996	.	.	+INF	-3.9697
REF .2000	.	.	+INF	-2.1643
REF .2004	.	.	+INF	-1.9199
MCAP .1984	.	.	+INF	-3.9397
MCAP .1988	.	.	+INF	-8.8563
MCAP .1992	.	.	+INF	-5.6890
MCAP .1996	.	.	+INF	-3.6453
MCAP .2000	.	.	+INF	-2.2575
MCAP .2004	.	.	+INF	-2.0925
MREST.1984	.	.	+INF	-2.4959
MREST.1988	.	.	+INF	-8.8200
MREST.1992	.	.	+INF	-4.4932
MREST.1996	.	.	+INF	-2.6715
MREST.2000	.	.	+INF	-1.1643
MREST.2004	.	.	+INF	-1.3173

---- VAR INV INVESTMENT BY SECTOR OF ORIGIN I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	.	27.8011	+INF	.
AGR .1988	.	33.2256	+INF	.
AGR .1992	.	38.1785	+INF	.
AGR .1996	.	39.2473	+INF	.
AGR .2000	.	53.1414	+INF	.
AGR .2004	.	53.9822	+INF	.
MIN .1984	.	0.6026	+INF	.
MIN .1988	.	0.3654	+INF	.
MIN .1992	.	0.4016	+INF	.
MIN .1996	.	0.4498	+INF	.
MIN .2000	.	0.5246	+INF	.
MIN .2004	.	0.7082	+INF	.
OIL .1984	.	0.4720	+INF	.
OIL .1988	.	0.5087	+INF	.
OIL .1992	.	0.5333	+INF	.
OIL .1996	.	0.5838	+INF	.
OIL .2000	.	0.6308	+INF	.
OIL .2004	.	0.7206	+INF	.
REF .1984	.	0.3012	+INF	.
REF .1988	.	0.4090	+INF	.
REF .1992	.	0.4892	+INF	.
REF .1996	.	0.5963	+INF	.
REF .2000	.	0.6490	+INF	.
REF .2004	.	0.7254	+INF	.
PETR .1984	.	0.0770	+INF	.
PETR .1988	.	0.0789	+INF	.
PETR .1992	.	0.0840	+INF	.
PETR .1996	.	0.1060	+INF	.
PETR .2000	.	0.1098	+INF	.
PETR .2004	.	0.1105	+INF	.
MCAP .1984	.	403.9043	+INF	.
MCAP .1988	.	349.1991	+INF	.
MCAP .1992	.	347.5108	+INF	.
MCAP .1996	.	474.7860	+INF	.
MCAP .2000	.	385.6209	+INF	.
MCAP .2004	.	503.0023	+INF	.
MREST.1984	.	67.9972	+INF	.
MREST.1988	.	35.2726	+INF	.
MREST.1992	.	38.1737	+INF	.
MREST.1996	.	48.4531	+INF	.
MREST.2000	.	59.1230	+INF	.
MREST.2004	.	71.6459	+INF	.
CONST.1984	.	691.9178	+INF	.
CONST.1988	.	613.4610	+INF	.
CONST.1992	.	625.6064	+INF	.
CONST.1996	.	643.8816	+INF	.
CONST.2000	.	650.9998	+INF	.
CONST.2004	.	721.1973	+INF	.
ELEC .1984	.	2.6119	+INF	.
ELEC .1988	.	2.0124	+INF	.
ELEC .1992	.	2.2776	+INF	.
ELEC .1996	.	3.0717	+INF	.
ELEC .2000	.	3.8902	+INF	.
ELEC .2004	.	4.3672	+INF	.
TRANS.1984	.	0.5156	+INF	.
TRANS.1988	.	0.3287	+INF	.
TRANS.1992	.	0.3766	+INF	.
TRANS.1996	.	0.4525	+INF	.
TRANS.2000	.	0.6017	+INF	.
TRANS.2004	.	0.7125	+INF	.

COM	.1984	.	166.3900	+INF	.
COM	.1988	.	119.0906	+INF	.
COM	.1992	.	122.3627	+INF	.
COM	.1996	.	147.7155	+INF	.
COM	.2000	.	226.9301	+INF	.
COM	.2004	.	236.0067	+INF	.
SER	.1984	.	31.5194	+INF	.
SER	.1988	.	26.1723	+INF	.
SER	.1992	.	27.2583	+INF	.
SER	.1996	.	30.4161	+INF	.
SER	.2000	.	40.0725	+INF	.
SER	.2004	.	41.1716	+INF	.
GOV	.1984	.	.	+INF	.
GOV	.1988	.	.	+INF	.
GOV	.1992	.	.	+INF	.
GOV	.1996	.	.	+INF	.
GOV	.2000	.	.	+INF	.
GOV	.2004	.	.	+INF	.

---- VAR OILEXP ENDOGENOUS EXPORTS OF OIL AND GAS YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	257.7115	+INF	EPS
1988	.	187.5394	+INF	.
1992	.	203.6486	+INF	.
1996	.	225.2053	+INF	EPS
2000	.	235.9165	+INF	EPS
2004	.	287.8643	+INF	.

---- VAR MCAPEXP ENDOG EXPORTS OF MANUFACTURING CAPITAL GOODS YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	54.8060	+INF	.
1988	.	178.8311	+INF	.
1992	.	309.3247	+INF	.
1996	.	457.8840	+INF	.
2000	.	546.5123	+INF	.
2004	.	543.1903	+INF	.

---- VAR MRESTEXP ENDOG EXPORTS OF MANUF CONSUMP & INTERM GOODS YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	108.9843	+INF	.
1988	.	354.5745	+INF	.
1992	.	464.0209	+INF	.
1996	.	632.3391	+INF	.
2000	.	668.2877	+INF	.
2004	.	815.4527	+INF	.

---- VAR NCI NON-COMPETITIVE IMPORTS ACROSS SECTORS YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	1084.2774	+INF	.
1988	.	1131.3015	+INF	.
1992	.	1125.6990	+INF	.
1996	.	1088.0338	+INF	.
2000	.	1012.9967	+INF	.
2004	.	1240.2580	+INF	.

---- VAR CAP CAPITAL STOCK FOR PRODUCTION OF GOOD I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	0.0100	1193.3791	+INF	.
AGR .1988	0.0100	1236.7135	+INF	.
AGR .1992	0.0100	1355.2164	+INF	.
AGR .1996	0.0100	1412.1759	+INF	.
AGR .2000	0.0100	1481.8974	+INF	.
AGR .2004	0.0100	1603.9341	+INF	.
AGR .2008	0.0100	1773.2337	+INF	.
MIN .1984	0.0100	92.7632	+INF	.
MIN .1988	0.0100	155.8210	+INF	.
MIN .1992	0.0100	222.3557	+INF	.
MIN .1996	0.0100	296.8922	+INF	.
MIN .2000	0.0100	330.5996	+INF	.
MIN .2004	0.0100	411.3014	+INF	.
MIN .2008	0.0100	468.7363	+INF	.
OIL .1984	0.0100	650.9578	+INF	.
OIL .1988	0.0100	720.9140	+INF	.
OIL .1992	0.0100	832.8493	+INF	.
OIL .1996	0.0100	885.0826	+INF	.
OIL .2000	0.0100	969.5539	+INF	.
OIL .2004	0.0100	1047.0900	+INF	.
OIL .2008	0.0100	1144.8506	+INF	.
REF .1984	0.0100	149.2138	+INF	.
REF .1988	0.0100	216.3633	+INF	.
REF .1992	0.0100	277.6988	+INF	.
REF .1996	0.0100	319.3937	+INF	.
REF .2000	0.0100	374.0709	+INF	.
REF .2004	0.0100	405.5843	+INF	.
REF .2008	0.0100	489.4979	+INF	.
PETR .1984	0.0100	19.4851	+INF	.
PETR .1988	0.0100	25.5743	+INF	.
PETR .1992	0.0100	34.7341	+INF	.
PETR .1996	0.0100	43.9593	+INF	.
PETR .2000	0.0100	49.2445	+INF	.
PETR .2004	0.0100	52.5853	+INF	.
PETR .2008	0.0100	62.1617	+INF	.
MCAP .1984	0.0100	901.5417	+INF	.
MCAP .1988	0.0100	1162.5340	+INF	.
MCAP .1992	0.0100	1570.6198	+INF	.
MCAP .1996	0.0100	2046.6025	+INF	.
MCAP .2000	0.0100	2582.6936	+INF	.
MCAP .2004	0.0100	2771.9985	+INF	.
MCAP .2008	0.0100	3006.9358	+INF	.
MREST.1984	0.0100	2309.0109	+INF	.
MREST.1988	0.0100	2794.6926	+INF	.
MREST.1992	0.0100	2932.2329	+INF	.
MREST.1996	0.0100	3177.5653	+INF	.
MREST.2000	0.0100	3468.1907	+INF	.
MREST.2004	0.0100	3505.0421	+INF	.
MREST.2008	0.0100	3926.9980	+INF	.
CONST.1984	0.0100	89.3661	+INF	.
CONST.1988	0.0100	96.0090	+INF	.
CONST.1992	0.0100	104.6641	+INF	.
CONST.1996	0.0100	155.0284	+INF	.
CONST.2000	0.0100	176.8444	+INF	.
CONST.2004	0.0100	205.9490	+INF	.
CONST.2008	0.0100	263.9895	+INF	.
ELEC .1984	0.0100	390.0120	+INF	.
ELEC .1988	0.0100	432.0884	+INF	.
ELEC .1992	0.0100	504.9070	+INF	.
ELEC .1996	0.0100	516.2428	+INF	.
ELEC .2000	0.0100	532.0134	+INF	.
ELEC .2004	0.0100	563.5024	+INF	.
ELEC .2008	0.0100	586.5161	+INF	.

TRANS.1984	0.0100	420.8330	+INF	.
TRANS.1988	0.0100	586.7848	+INF	.
TRANS.1992	0.0100	623.1436	+INF	.
TRANS.1996	0.0100	682.7668	+INF	.
TRANS.2000	0.0100	737.7833	+INF	.
TRANS.2004	0.0100	794.3897	+INF	.
TRANS.2008	0.0100	830.8334	+INF	.
COM .1984	0.0100	1780.1930	+INF	.
COM .1988	0.0100	1861.0160	+INF	.
COM .1992	0.0100	1968.8464	+INF	.
COM .1996	0.0100	2205.6311	+INF	.
COM .2000	0.0100	2659.2831	+INF	.
COM .2004	0.0100	3029.4360	+INF	.
COM .2008	0.0100	3197.0010	+INF	.
SER .1984	0.0100	1687.8506	+INF	.
SER .1988	0.0100	1727.7610	+INF	.
SER .1992	0.0100	1743.3884	+INF	.
SER .1996	0.0100	1806.5979	+INF	.
SER .2000	0.0100	1878.0061	+INF	.
SER .2004	0.0100	2268.2659	+INF	.
SER .2008	0.0100	2303.4468	+INF	.
GOV .1984	0.0100	1018.9489	+INF	.
GOV .1988	0.0100	1019.2489	+INF	.
GOV .1992	0.0100	1019.5489	+INF	.
GOV .1996	0.0100	1019.8489	+INF	.
GOV .2000	0.0100	1020.1489	+INF	.
GOV .2004	0.0100	1020.4489	+INF	.
GOV .2008	0.0100	1020.8989	+INF	.

---- VAR LD LABOUR BY SKILL CATEGORY S FOR PRODUCTION OF GOOD I

	LOWER	LEVEL	UPPER	MARGINA
AGR .RURAL .1984	3543.0878	5107.2584	+INF	.
AGR .RURAL .1988	3666.3634	5765.6818	+INF	.
AGR .RURAL .1992	3807.7749	6211.7432	+INF	.
AGR .RURAL .1996	4068.8063	6802.9341	+INF	.
AGR .RURAL .2000	4465.6898	7536.5684	+INF	.
AGR .RURAL .2004	4982.3194	8758.0363	+INF	.
AGR .URBAN-SKIL.1984	1207.8899	1207.8899	+INF	-6.760
AGR .URBAN-SKIL.1988	1249.9164	1249.9164	+INF	-4.750
AGR .URBAN-SKIL.1992	1298.1256	1298.1256	+INF	-2.274
AGR .URBAN-SKIL.1996	1387.1150	1387.1150	+INF	-1.131
AGR .URBAN-SKIL.2000	1522.4183	1522.4183	+INF	-0.463
AGR .URBAN-SKIL.2004	1698.5448	1698.5448	+INF	-0.406
AGR .URBAN-UNSK.1984	34.4152	56.3628	+INF	.
AGR .URBAN-UNSK.1988	35.6126	64.0730	+INF	.
AGR .URBAN-UNSK.1992	36.9862	61.8037	+INF	.
AGR .URBAN-UNSK.1996	39.5217	62.8655	+INF	.
AGR .URBAN-UNSK.2000	43.3768	65.4671	+INF	.
AGR .URBAN-UNSK.2004	48.3950	82.2667	+INF	.
MIN .RURAL .1984	63.3921	92.5085	+INF	.
MIN .RURAL .1988	90.2601	143.6982	+INF	.
MIN .RURAL .1992	84.9829	140.3505	+INF	.
MIN .RURAL .1996	83.1547	140.7526	+INF	.
MIN .RURAL .2000	83.9663	143.4598	+INF	.
MIN .RURAL .2004	87.5877	155.8685	+INF	.
MIN .URBAN-SKIL.1984	342.3176	342.3176	+INF	-5.772
MIN .URBAN-SKIL.1988	487.4046	487.4046	+INF	-4.337
MIN .URBAN-SKIL.1992	458.9076	458.9076	+INF	-2.148
MIN .URBAN-SKIL.1996	449.0356	449.0356	+INF	-1.116
MIN .URBAN-SKIL.2000	453.4178	453.4178	+INF	-0.581
MIN .URBAN-SKIL.2004	472.9733	472.9733	+INF	-0.380
MIN .URBAN-UNSK.1984	320.5831	477.2744	+INF	.
MIN .URBAN-UNSK.1988	456.4583	746.5470	+INF	.
MIN .URBAN-UNSK.1992	429.7706	652.8245	+INF	.
MIN .URBAN-UNSK.1996	420.5254	608.0708	+INF	EPS
MIN .URBAN-UNSK.2000	424.6293	582.5872	+INF	.

OIL	.RURAL	.1984	6.4348	20.0727	+INF	.
OIL	.RURAL	.1988	5.8029	15.9252	+INF	.
OIL	.RURAL	.1992	6.4487	25.0850	+INF	.
OIL	.RURAL	.1996	7.1670	31.4829	+INF	.
OIL	.RURAL	.2000	7.7403	38.0763	+INF	.
OIL	.RURAL	.2004	8.2045	56.9281	+INF	.
OIL	.URBAN-SKIL	.1984	78.2903	167.3766	+INF	.
OIL	.URBAN-SKIL	.1988	70.6018	121.7207	+INF	EPS
OIL	.URBAN-SKIL	.1992	78.4589	184.8272	+INF	.
OIL	.URBAN-SKIL	.1996	87.1984	226.3290	+INF	.
OIL	.URBAN-SKIL	.2000	94.1732	271.1842	+INF	.
OIL	.URBAN-SKIL	.2004	99.8215	389.2657	+INF	.
OIL	.URBAN-UNSK	.1984	10.7247	33.1393	+INF	.
OIL	.URBAN-UNSK	.1988	9.6715	26.4753	+INF	.
OIL	.URBAN-UNSK	.1992	10.7478	37.3376	+INF	.
OIL	.URBAN-UNSK	.1996	11.9450	43.5234	+INF	.
OIL	.URBAN-UNSK	.2000	12.9004	49.4807	+INF	.
OIL	.URBAN-UNSK	.2004	13.6742	79.9974	+INF	.
REF	.RURAL	.1984	4.7693	11.1703	+INF	.
REF	.RURAL	.1988	5.1954	16.2766	+INF	.
REF	.RURAL	.1992	5.5492	24.1441	+INF	EPS
REF	.RURAL	.1996	6.1037	31.3639	+INF	.
REF	.RURAL	.2000	6.9213	43.3565	+INF	.
REF	.RURAL	.2004	8.0474	41.7133	+INF	EPS
REF	.URBAN-SKIL	.1984	25.7545	100.3483	+INF	.
REF	.URBAN-SKIL	.1988	28.0550	134.0289	+INF	.
REF	.URBAN-SKIL	.1992	29.9658	191.6548	+INF	.
REF	.URBAN-SKIL	.1996	32.9601	242.9136	+INF	.
REF	.URBAN-SKIL	.2000	37.3750	332.6746	+INF	.
REF	.URBAN-SKIL	.2004	43.4558	307.2910	+INF	.
REF	.URBAN-UNSK	.1984	3.8155	20.1707	+INF	.
REF	.URBAN-UNSK	.1988	4.1563	29.5963	+INF	.
REF	.URBAN-UNSK	.1992	4.4394	39.3063	+INF	.
REF	.URBAN-UNSK	.1996	4.8830	47.4238	+INF	.
REF	.URBAN-UNSK	.2000	5.5370	61.6245	+INF	.
REF	.URBAN-UNSK	.2004	6.4379	64.1123	+INF	.
PETR	.RURAL	.1984	1.8900	2.1414	+INF	.
PETR	.RURAL	.1988	2.0489	2.3362	+INF	.
PETR	.RURAL	.1992	2.1570	2.9461	+INF	.
PETR	.RURAL	.1996	2.3272	3.7814	+INF	.
PETR	.RURAL	.2000	2.5744	4.5111	+INF	.
PETR	.RURAL	.2004	2.9060	4.5419	+INF	EPS
PETR	.URBAN-SKIL	.1984	9.4499	19.6250	+INF	.
PETR	.URBAN-SKIL	.1988	10.2444	19.6250	+INF	.
PETR	.URBAN-SKIL	.1992	10.7849	23.8572	+INF	.
PETR	.URBAN-SKIL	.1996	11.6358	29.8768	+INF	.
PETR	.URBAN-SKIL	.2000	12.8719	35.3110	+INF	.
PETR	.URBAN-SKIL	.2004	14.5302	34.1333	+INF	.
PETR	.URBAN-UNSK	.1984	0.9450	3.9984	+INF	.
PETR	.URBAN-UNSK	.1988	1.0244	4.3925	+INF	.
PETR	.URBAN-UNSK	.1992	1.0785	4.9594	+INF	.
PETR	.URBAN-UNSK	.1996	1.1636	5.9121	+INF	.
PETR	.URBAN-UNSK	.2000	1.2872	6.6299	+INF	.
PETR	.URBAN-UNSK	.2004	1.4530	7.2183	+INF	.
MCAP	.RURAL	.1984	330.0388	748.7150	+INF	.
MCAP	.RURAL	.1988	536.5032	1222.6123	+INF	.
MCAP	.RURAL	.1992	484.4430	1243.4888	+INF	.
MCAP	.RURAL	.1996	455.1604	1275.2820	+INF	.
MCAP	.RURAL	.2000	441.5736	1198.1795	+INF	.
MCAP	.RURAL	.2004	447.7929	1634.8876	+INF	.
MCAP	.URBAN-SKIL	.1984	2008.0675	3142.6629	+INF	.
MCAP	.URBAN-SKIL	.1988	3264.2663	4703.9292	+INF	EPS
MCAP	.URBAN-SKIL	.1992	2947.5148	4611.9735	+INF	EPS
MCAP	.URBAN-SKIL	.1996	2769.3497	4614.9196	+INF	EPS
MCAP	.URBAN-SKIL	.2000	2686.6829	4295.6013	+INF	EPS
MCAP	.URBAN-SKIL	.2004	2724.5230	5627.2975	+INF	EPS

MCAP .URBAN-UNSK.1984	298.2279	701.0281	+INF	.
MCAP .URBAN-UNSK.1988	484.7920	1152.7282	+INF	.
MCAP .URBAN-UNSK.1992	437.7497	1049.6792	+INF	.
MCAP .URBAN-UNSK.1996	411.2896	999.8529	+INF	.
MCAP .URBAN-UNSK.2000	399.0123	883.0494	+INF	.
MCAP .URBAN-UNSK.2004	404.6321	1302.9238	+INF	.
MREST.RURAL .1984	209.6272	320.6139	+INF	.
MREST.RURAL .1988	227.3397	351.2456	+INF	.
MREST.RURAL .1992	237.9449	515.3506	+INF	.
MREST.RURAL .1996	256.2077	676.6067	+INF	.
MREST.RURAL .2000	284.1440	884.1535	+INF	.
MREST.RURAL .2004	322.8211	1042.5761	+INF	.
MREST.URBAN-SKIL.1984	1272.9923	1374.7834	+INF	EPS
MREST.URBAN-SKIL.1988	1380.5546	1380.5546	+INF	-0.069
MREST.URBAN-SKIL.1992	1444.9559	1952.6229	+INF	EPS
MREST.URBAN-SKIL.1996	1555.8595	2501.2946	+INF	EPS
MREST.URBAN-SKIL.2000	1725.5068	3238.1759	+INF	.
MREST.URBAN-SKIL.2004	1960.3796	3665.9827	+INF	EPS
MREST.URBAN-UNSK.1984	189.9186	305.3773	+INF	.
MREST.URBAN-UNSK.1988	205.9659	336.8873	+INF	.
MREST.URBAN-UNSK.1992	215.5740	442.5406	+INF	EPS
MREST.URBAN-UNSK.1996	232.1198	539.6370	+INF	.
MREST.URBAN-UNSK.2000	257.4296	662.8669	+INF	.
MREST.URBAN-UNSK.2004	292.4704	845.2291	+INF	.
CONST.RURAL .1984	140.6669	284.5248	+INF	.
CONST.RURAL .1988	86.9512	136.9826	+INF	.
CONST.RURAL .1992	108.5019	177.3185	+INF	.
CONST.RURAL .1996	134.1648	224.7204	+INF	.
CONST.RURAL .2000	166.7816	281.9732	+INF	.
CONST.RURAL .2004	191.1200	397.9843	+INF	.
CONST.URBAN-SKIL.1984	552.2960	773.6055	+INF	EPS
CONST.URBAN-SKIL.1988	341.3937	341.3937	+INF	-0.251
CONST.URBAN-SKIL.1992	426.0074	426.0074	+INF	-0.742
CONST.URBAN-SKIL.1996	526.7671	526.7671	+INF	-1.137
CONST.URBAN-SKIL.2000	654.8293	654.8293	+INF	-1.339
CONST.URBAN-SKIL.2004	750.3881	887.3525	+INF	EPS
CONST.URBAN-UNSK.1984	154.9281	326.5125	+INF	.
CONST.URBAN-UNSK.1988	95.7666	158.2939	+INF	.
CONST.URBAN-UNSK.1992	119.5021	183.4550	+INF	.
CONST.URBAN-UNSK.1996	147.7668	215.9401	+INF	.
CONST.URBAN-UNSK.2000	183.6904	254.7016	+INF	.
CONST.URBAN-UNSK.2004	210.4962	388.7388	+INF	.
ELEC .RURAL .1984	7.8866	30.1176	+INF	.
ELEC .RURAL .1988	9.7167	37.4392	+INF	.
ELEC .RURAL .1992	9.7713	49.8717	+INF	.
ELEC .RURAL .1996	10.2385	61.0976	+INF	.
ELEC .RURAL .2000	11.1480	75.8871	+INF	.
ELEC .RURAL .2004	12.5647	82.3138	+INF	.
ELEC .URBAN-SKIL.1984	119.6137	329.9148	+INF	.
ELEC .URBAN-SKIL.1988	147.3704	375.9223	+INF	.
ELEC .URBAN-SKIL.1992	148.1987	482.7240	+INF	.
ELEC .URBAN-SKIL.1996	155.2839	577.0078	+INF	.
ELEC .URBAN-SKIL.2000	169.0774	710.0186	+INF	EPS
ELEC .URBAN-SKIL.2004	190.5641	739.4083	+INF	EPS
ELEC .URBAN-UNSK.1984	24.9743	105.8915	+INF	.
ELEC .URBAN-UNSK.1988	30.7696	132.5519	+INF	.
ELEC .URBAN-UNSK.1992	30.9426	158.0849	+INF	EPS
ELEC .URBAN-UNSK.1996	32.4219	179.8769	+INF	.
ELEC .URBAN-UNSK.2000	35.3019	210.0161	+INF	.
ELEC .URBAN-UNSK.2004	39.7881	246.3345	+INF	.
TRANS.RURAL .1984	96.7104	140.5029	+INF	.
TRANS.RURAL .1988	108.0269	171.2195	+INF	.
TRANS.RURAL .1992	110.9090	194.2767	+INF	.
TRANS.RURAL .1996	116.9768	257.0730	+INF	.
TRANS.RURAL .2000	126.8534	338.3020	+INF	.
TRANS.RURAL .2004	141.3970	367.5653	+INF	.

TRANS.URBAN-SKIL.1984	481.6559	481.6559	+INF	-0.94
TRANS.URBAN-SKIL.1988	538.0163	538.0163	+INF	-0.99
TRANS.URBAN-SKIL.1992	552.3703	588.4858	+INF	EPS
TRANS.URBAN-SKIL.1996	582.5904	759.7744	+INF	EPS
TRANS.URBAN-SKIL.2000	631.7798	990.5512	+INF	EPS
TRANS.URBAN-SKIL.2004	704.2126	1033.2770	+INF	EPS
TRANS.URBAN-UNSK.1984	69.2143	105.1801	+INF	.
TRANS.URBAN-UNSK.1988	77.3134	129.0686	+INF	.
TRANS.URBAN-UNSK.1992	79.3760	131.1187	+INF	.
TRANS.URBAN-UNSK.1996	83.7187	161.1445	+INF	.
TRANS.URBAN-UNSK.2000	90.7873	199.3411	+INF	.
TRANS.URBAN-UNSK.2004	101.1959	234.2043	+INF	.
COM .RURAL .1984	235.0736	413.3256	+INF	.
COM .RURAL .1988	242.0093	436.9142	+INF	.
COM .RURAL .1992	251.7934	602.9240	+INF	.
COM .RURAL .1996	268.5693	798.3123	+INF	.
COM .RURAL .2000	295.0068	1042.9933	+INF	.
COM .RURAL .2004	333.6804	999.1543	+INF	.
COM .URBAN-SKIL.1984	345.6334	418.9140	+INF	.
COM .URBAN-SKIL.1988	355.8310	405.9004	+INF	EPS
COM .URBAN-SKIL.1992	370.2168	539.9566	+INF	.
COM .URBAN-SKIL.1996	394.8827	697.5608	+INF	.
COM .URBAN-SKIL.2000	433.7542	902.8902	+INF	EPS
COM .URBAN-SKIL.2004	490.6169	830.4163	+INF	EPS
COM .URBAN-UNSK.1984	1298.8086	2345.6949	+INF	.
COM .URBAN-UNSK.1988	1337.1291	2496.8625	+INF	.
COM .URBAN-UNSK.1992	1391.1873	3084.8756	+INF	.
COM .URBAN-UNSK.1996	1483.8762	3793.7006	+INF	.
COM .URBAN-UNSK.2000	1629.9460	4659.1315	+INF	.
COM .URBAN-UNSK.2004	1843.6225	4826.4080	+INF	.
SER .RURAL .1984	502.0174	1184.5244	+INF	.
SER .RURAL .1988	544.3746	1319.6849	+INF	.
SER .RURAL .1992	571.2976	1885.1801	+INF	.
SER .RURAL .1996	612.4953	2443.9811	+INF	.
SER .RURAL .2000	671.7198	3088.6928	+INF	.
SER .RURAL .2004	752.4562	3364.8494	+INF	.
SER .URBAN-SKIL.1984	1001.1931	1629.1528	+INF	EPS
SER .URBAN-SKIL.1988	1085.6679	1663.7145	+INF	.
SER .URBAN-SKIL.1992	1139.3615	2291.0488	+INF	.
SER .URBAN-SKIL.1996	1221.5236	2897.9595	+INF	.
SER .URBAN-SKIL.2000	1339.6374	3628.3848	+INF	.
SER .URBAN-SKIL.2004	1500.6531	3795.0209	+INF	EPS
SER .URBAN-UNSK.1984	906.4729	2195.3060	+INF	EPS
SER .URBAN-UNSK.1988	982.9557	2462.8649	+INF	EPS
SER .URBAN-UNSK.1992	1031.5695	3149.9217	+INF	.
SER .URBAN-UNSK.1996	1105.9584	3792.7996	+INF	EPS
SER .URBAN-UNSK.2000	1212.8978	4505.7800	+INF	EPS
SER .URBAN-UNSK.2004	1358.6803	5307.9757	+INF	.
GOV .RURAL .1984	66.5281	88.5244	+INF	.
GOV .RURAL .1988	71.8504	106.9837	+INF	.
GOV .RURAL .1992	77.5985	132.3207	+INF	.
GOV .RURAL .1996	83.8065	160.6121	+INF	.
GOV .RURAL .2000	90.5110	192.8465	+INF	.
GOV .RURAL .2004	97.7521	222.5811	+INF	.
GOV .URBAN-SKIL.1984	95.0401	121.7533	+INF	.
GOV .URBAN-SKIL.1988	102.6434	134.8734	+INF	.
GOV .URBAN-SKIL.1992	110.8550	160.8086	+INF	.
GOV .URBAN-SKIL.1996	119.7236	190.4463	+INF	.
GOV .URBAN-SKIL.2000	129.3014	226.5428	+INF	.
GOV .URBAN-SKIL.2004	139.6459	251.0365	+INF	.
GOV .URBAN-UNSK.1984	113.1841	164.0642	+INF	.
GOV .URBAN-UNSK.1988	122.2390	199.6586	+INF	.
GOV .URBAN-UNSK.1992	132.0182	221.0929	+INF	.
GOV .URBAN-UNSK.1996	142.5799	249.2529	+INF	.
GOV .URBAN-UNSK.2000	153.9862	281.3241	+INF	.
GOV .URBAN-UNSK.2004	166.3055	351.1168	+INF	.

---- VAR DK INVESTMENT BY SECTOR OF DESTINATION I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1980	0.1000	90.3030	+INF	.
AGR .1984	0.1000	57.1283	+INF	EPS
AGR .1988	0.1000	84.6995	+INF	EPS
AGR .1992	0.1000	96.3248	+INF	EPS
AGR .1996	0.1000	88.9066	+INF	EPS
AGR .2000	0.1000	160.1000	+INF	.
AGR .2004	0.1000	196.6477	+INF	.
MIN .1980	0.1000	36.0706	+INF	.
MIN .1984	0.1000	64.0511	+INF	.
MIN .1988	0.1000	67.3081	+INF	.
MIN .1992	0.1000	76.6316	+INF	.
MIN .1996	0.1000	63.3965	+INF	EPS
MIN .2000	0.1000	80.4918	+INF	.
MIN .2004	0.1000	55.5637	+INF	.
OIL .1980	0.1000	35.5028	+INF	.
OIL .1984	0.1000	71.2017	+INF	EPS
OIL .1988	0.1000	120.8741	+INF	EPS
OIL .1992	0.1000	83.3332	+INF	EPS
OIL .1996	0.1000	88.3786	+INF	.
OIL .2000	0.1000	85.0795	+INF	EPS
OIL .2004	0.1000	102.0602	+INF	.
REF .1980	0.1000	20.1439	+INF	.
REF .1984	0.1000	44.2358	+INF	EPS
REF .1988	0.1000	60.4480	+INF	.
REF .1992	0.1000	65.4360	+INF	EPS
REF .1996	0.1000	71.0695	+INF	EPS
REF .2000	0.1000	60.1000	+INF	.
REF .2004	0.1000	83.2824	+INF	.
PETR .1980	0.1000	4.5470	+INF	.
PETR .1984	0.1000	6.1331	+INF	.
PETR .1988	0.1000	10.0268	+INF	.
PETR .1992	0.1000	12.6842	+INF	.
PETR .1996	0.1000	14.6501	+INF	.
PETR .2000	0.1000	8.1127	+INF	.
PETR .2004	0.1000	11.1530	+INF	.
MCAP .1980	0.1000	170.3612	+INF	.
MCAP .1984	0.1000	326.6336	+INF	.
MCAP .1988	0.1000	460.3102	+INF	.
MCAP .1992	0.1000	544.9654	+INF	.
MCAP .1996	0.1000	680.0381	+INF	.
MCAP .2000	0.1000	740.1132	+INF	.
MCAP .2004	0.1000	863.4688	+INF	.
MREST.1980	0.1000	220.1296	+INF	.
MREST.1984	0.1000	282.5965	+INF	EPS
MREST.1988	0.1000	392.4897	+INF	EPS
MREST.1992	0.1000	219.0163	+INF	.
MREST.1996	0.1000	333.7090	+INF	EPS
MREST.2000	0.1000	430.0965	+INF	.
MREST.2004	0.1000	442.3734	+INF	.
CONST.1980	0.1000	20.9122	+INF	EPS
CONST.1984	0.1000	10.6756	+INF	.
CONST.1988	0.1000	9.3568	+INF	.
CONST.1992	0.1000	10.5012	+INF	.
CONST.1996	0.1000	60.0874	+INF	.
CONST.2000	0.1000	44.6419	+INF	.
CONST.2004	0.1000	37.5126	+INF	.
ELEC .1980	0.1000	8.6436	+INF	EPS
ELEC .1984	0.1000	37.3720	+INF	EPS
ELEC .1988	0.1000	43.0629	+INF	EPS
ELEC .1992	0.1000	80.9572	+INF	EPS
ELEC .1996	0.1000	15.6046	+INF	EPS
ELEC .2000	0.1000	20.3398	+INF	.
ELEC .2004	0.1000	37.1290	+INF	.

TRANS.1980	0.1000	101.5638	+INF	EPS
TRANS.1984	0.1000	177.3907	+INF	EPS
TRANS.1988	0.1000	60.5103	+INF	EPS
TRANS.1992	0.1000	57.4462	+INF	EPS
TRANS.1996	0.1000	61.9096	+INF	EPS
TRANS.2000	0.1000	60.1000	+INF	.
TRANS.2004	0.1000	77.2071	+INF	.
COM .1980	0.1000	314.3903	+INF	EPS
COM .1984	0.1000	162.8051	+INF	EPS
COM .1988	0.1000	146.2516	+INF	.
COM .1992	0.1000	126.0688	+INF	.
COM .1996	0.1000	267.4138	+INF	.
COM .2000	0.1000	296.1230	+INF	EPS
COM .2004	0.1000	231.5987	+INF	.
SER .1980	0.1000	180.1320	+INF	.
SER .1984	0.1000	81.8880	+INF	.
SER .1988	0.1000	80.7589	+INF	EPS
SER .1992	0.1000	55.1235	+INF	EPS
SER .1996	0.1000	77.2710	+INF	EPS
SER .2000	0.1000	91.1653	+INF	EPS
SER .2004	0.1000	99.8620	+INF	.
GOV .1980	0.1000	0.1000	+INF	-28.1678
GOV .1984	0.1000	0.1000	+INF	-16.1960
GOV .1988	0.1000	0.1000	+INF	-9.5420
GOV .1992	0.1000	0.1000	+INF	-5.2852
GOV .1996	0.1000	0.1000	+INF	-2.2058
GOV .2000	0.1000	0.1000	+INF	-0.1773
GOV .2004	0.1000	0.1500	+INF	.

---- VAR EXT EXTRACTION OF OIL AND GAS RESERVES YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	0.0100	1393.0000	1393.0000	3.3003
1988	0.0100	1256.2000	1256.2000	1.1595
1992	0.0100	1396.0000	1396.0000	0.5323
1996	0.0100	1551.5000	1551.5000	0.3364
2000	0.0100	1675.6000	1675.6000	0.1954
2004	0.0100	1776.1000	1776.1000	0.1401

---- VAR RES OIL AND GAS RESERVES YEAR

	LOWER	LEVEL	UPPER	MARGINAL
1988	71750.0000	71750.0000	71750.0000	EPS
1992	.	66725.2000	+INF	.
1996	.	61141.2000	+INF	.
2000	.	54935.2000	+INF	.
2004	.	48232.8000	+INF	.
2008	.	41128.4000	+INF	.

---- VAR BOR NET FOREIGN BORROWING YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1980	.	.	.	-62.8951
1984	1234.1000	1234.1000	1234.1000	-39.4721
1988	-INF	-261.6177	+INF	-21.4092
1992	-INF	-180.9640	+INF	-11.3007
1996	-INF	-167.2051	+INF	-5.6280
2000	-INF	-148.1388	+INF	-2.5359
2004	-INF	-151.0622	+INF	-0.0026
2008	-INF	.	+INF	-0.0026

---- VAR DEBT ACCUMULATED FOREIGN DEBT YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1980	1012.1000	1012.1000	1012.1000	-62.8951
1984	.	2246.2000	+INF	.
1988	.	1984.5823	+INF	.
1992	.	1803.6183	+INF	.
1996	.	1636.4132	+INF	.
2000	.	1488.2744	+INF	.
2004	.	1337.2122	+INF	.
2008	.	1337.2122	+INF	.

---- VAR IP INTEREST PAYMENTS ON FOREIGN DEBT YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	179.6960	+INF	.
1988	.	158.7666	+INF	.
1992	.	144.2895	+INF	.
1996	.	130.9131	+INF	.
2000	.	119.0620	+INF	.
2004	.	106.9770	+INF	.

---- VAR CON CONSUMPTION DEMAND FOR GOOD I YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
AGR .1984	0.0100	242.5584	+INF	.
AGR .1988	0.0100	251.5415	+INF	.
AGR .1992	0.0100	276.9016	+INF	.
AGR .1996	0.0100	288.3410	+INF	.
AGR .2000	0.0100	271.3555	+INF	.
AGR .2004	0.0100	263.6552	+INF	.
MIN .1984	0.0100	0.1797	+INF	EPS
MIN .1988	0.0100	0.2041	+INF	EPS
MIN .1992	0.0100	0.2304	+INF	EPS
MIN .1996	0.0100	0.2079	+INF	EPS
MIN .2000	0.0100	0.3112	+INF	.
MIN .2004	0.0100	0.3337	+INF	EPS
OIL .1984	.	.	+INF	-21.5866
OIL .1988	.	.	+INF	-9.8010
OIL .1992	.	.	+INF	-5.9235
OIL .1996	.	.	+INF	-3.5903
OIL .2000	.	.	+INF	-2.1134
OIL .2004	.	.	+INF	-1.8701
REF .1984	0.0100	46.5429	+INF	.
REF .1988	0.0100	52.2895	+INF	.
REF .1992	0.0100	60.8466	+INF	.
REF .1996	0.0100	73.0734	+INF	.
REF .2000	0.0100	91.3406	+INF	.
REF .2004	0.0100	117.8490	+INF	.
PETR .1984	.	.	+INF	-18.2966
PETR .1988	.	.	+INF	-8.1253
PETR .1992	.	.	+INF	-6.9994
PETR .1996	.	.	+INF	-4.1603
PETR .2000	.	.	+INF	-2.4308
PETR .2004	.	.	+INF	-1.9614
MCAP .1984	0.0100	130.4816	+INF	EPS
MCAP .1988	0.0100	141.3899	+INF	.
MCAP .1992	0.0100	169.5773	+INF	EPS
MCAP .1996	0.0100	195.8844	+INF	.
MCAP .2000	0.0100	193.9491	+INF	.
MCAP .2004	0.0100	238.3708	+INF	.

MREST.1984	0.0100	958.3049	+INF	.
MREST.1988	0.0100	1050.0965	+INF	.
MREST.1992	0.0100	1206.1361	+INF	.
MREST.1996	0.0100	1349.7125	+INF	.
MREST.2000	0.0100	1298.6389	+INF	.
MREST.2004	0.0100	1410.2430	+INF	.
CONST.1984	.	.	+INF	-21.1450
CONST.1988	.	.	+INF	-12.2946
CONST.1992	.	.	+INF	-6.6119
CONST.1996	.	.	+INF	-2.6141
CONST.2000	.	.	+INF	-2.3650
CONST.2004	.	.	+INF	-2.2228
ELEC .1984	0.0100	42.8222	+INF	EPS
ELEC .1988	0.0100	50.0119	+INF	.
ELEC .1992	0.0100	60.0735	+INF	.
ELEC .1996	0.0100	70.1134	+INF	.
ELEC .2000	0.0100	74.6924	+INF	.
ELEC .2004	0.0100	81.5182	+INF	.
TRANS.1984	0.0100	302.3402	+INF	.
TRANS.1988	0.0100	348.0165	+INF	.
TRANS.1992	0.0100	383.2140	+INF	.
TRANS.1996	0.0100	444.0272	+INF	.
TRANS.2000	0.0100	478.7646	+INF	.
TRANS.2004	0.0100	511.6154	+INF	.
COM .1984	0.0100	933.0003	+INF	.
COM .1988	0.0100	1092.0373	+INF	.
COM .1992	0.0100	1261.5498	+INF	.
COM .1996	0.0100	1469.2008	+INF	.
COM .2000	0.0100	1798.5244	+INF	.
COM .2004	0.0100	1825.3744	+INF	.
SER .1984	0.0100	747.0626	+INF	.
SER .1988	0.0100	853.6092	+INF	.
SER .1992	0.0100	998.8189	+INF	.
SER .1996	0.0100	1169.0038	+INF	.
SER .2000	0.0100	1262.0941	+INF	.
SER .2004	0.0100	1348.1371	+INF	.
GOV .1984	.	.	+INF	-18.1555
GOV .1988	.	.	+INF	-11.6225
GOV .1992	.	.	+INF	-7.3436
GOV .1996	.	.	+INF	-4.3580
GOV .2000	.	.	+INF	-2.5622
GOV .2004	.	.	+INF	-2.0307

---- VAR UTI UTILITY OF AGGREGATE CONSUMPTION YEAR T

	LOWER	LEVEL	UPPER	MARGINAL
1984	.	66.0946	+INF	.
1988	.	54.5640	+INF	.
1992	.	45.6367	+INF	.
1996	.	37.3128	+INF	.
2000	.	29.4892	+INF	.
2004	.	19.4003	+INF	.

```
**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
                             0     ERRORS

**** FILE SUMMARY FOR USER ECRPQ

RESTART    ARNE     WORK*     A
INPUT      ARNE2    GAMS      A
OUTPUT     ARNE2    LISTING   A

EXECUTION TIME       =       11.460 SECONDS
```

REFERENCES.

ADELMAN, I. and F.T. SPARROW (1966) "Experiments with Linear and Piece-wise Linear Dynamic Programming Models" and comments by K. A. FOX in I. ADELMAN and E. THORBECKE (eds.) The Theory and Design of Economic Development. (John Hopkins University Press, Baltimore), pp. 291-317.

AKINS, J., (1973). "The Oil crisis: This time the wolf is here", Foreign Affairs 51, pp. 462-490.

AMUZEGAR, J. (1982). "Oil Wealth: A Very Mixed Blessing". Foreign Affairs, pp. 814-34.

ARROW, K.J., H.B. CHENERY, B.S. MINHAS, and R. SOLOW (1961). "Capital-Labour Substitution and Economic Efficiency", Review of Economics and Statistics, 43, 3 (August), pp. 225-250.

ARROW, K.J. and F.H. HAHN (1971). General Competitive Analysis. San Francisco: Holden-day.

AUTY, R. and A.H. GELB (1984). "The Deployment of Oil Rents in a Small Parliamentary Democracy: the Case of Trinidad and Tobago", Discussion Paper No. 131, Development Research Department (DRD), World Bank.

BALASSA, B.A. (1986). "Economic Prospects and Policies in Mexico", Discussion Paper No. 178, DRD, World Bank.

BANCO de MEXICO, Carpeta Historica de Indicadores Economicos 1960-1988. Mexico.

BARKER, T., and V. BRAILOVSKY (1981). Oil or Industry: Energy Industrialisation, and Economic Policy in Canada, Mexico, the Netherlands, Norway and the United Kingdom. London: Academic Press.

BARRO, R., and H. GROSSMAN (1971). "Output and Employment in General Disequilibrium", American Economic Review, 61, pp. 82-93.

BELL, C., P. HAZELL, and R. SLADE (1982). Project Evaluation in Regional Perspective. The World Bank, Washington, D.C.

BELL, C. and T.N. SRINIVASAN (1984). "On the Uses and Abuses of Economy-wide Models in Development Policy Analysis", in M. SYRQUIN, et al (ed.).Economic Structure and Performance: Essays in Honor of H. B. CHENERY. London: Academic Press.

BELTRAN del RIO, Abel (1980). "El Sindrome del Petroleo Mexicano: primeros sintomas, medidas preventivas y pronosticos", Comercio Exterior, vol.30, pp. 556-569.

BERGMAN, L. (1988). "Energy Policy Modeling: A Survey of General Equilibrium Approaches", Journal of Policy Modeling, pp. 377-399.

BERGSMAN, J. (1980). "Income Distribution and Poverty in Mexico", World Bank Staff Working paper, No. 395.

BERNDT, E., and D. WOOD (1979). "Engineering and Econometric Interpretations of Energy-Capital Complementarity", American Economic Review, 69, pp. 342-54.

BLANEY, J.C. (1983). "Mexico's Natural Gas Export Potential", in Government and Energy Policy. R.L. ITTEILAG (ed.) IAEE, Westview Press.

BLITZER, C.R., P.B. CLARK and L. TAYLOR (1975). Economy-Wide Models and Development Planning. (Oxford University Press, Oxford).

BLITZER, C.R., A. MEERAUS and A. STOUTJESDIK (1975). "A Dynamic Model of Opec trade and Production", Journal of Development Economics 2, no. 4, pp. 319-335.

BLITZER, C.R., and R.S. ECKAUS (1983). "Modelling Long-run Energy Policy in Mexico: A Linear Programming Approach", MIT Energy Lab Working Paper No. MIT-EL 83-007WP (Cambridge, MA).

-------, (1986a). "Energy-economy Interactions in Mexico: A Multiperiod General Equilibrium Model", Journal of Development Economics 21, pp. 259-281.

-------, (1986b). "Modeling Energy-Economy Interactions in Small Developing Countries: A Case Study of Sri Lanka", Journal of Policy Modeling, pp. 471-501.

BORGES, A.M., and L.H. GOULDER (1983). "Decompossing the Impact of Higher Energy Prices on Long-term Growth", in Applied General Equilibrium Analysis. edited by H. SCARF and J.B. SHOVEN (Cambridge University Press, Cambridge).

BROOKE, A., A. DRUD, and A. MEERAUS (1984). "High Level Modeling Systems and Nonlinear Programmings in Numerical Optimization", Discussion Paper No. 113, DRD, World Bank.

-------, (1985). "Modeling Systems and Nonlinear Programming in a Research Environment", Discussion Paper No. 118, DRD, World Bank.

BRUNO, M. (1966). "A Programming Model for Israel", in I. ADELMAN and E. THORBECKE (eds.) The Theory and Design of Economic Development. (John Hopkins University Press, Baltimore).

BRUNO, M. (1975). "Planning Models, Shadow Prices and Project Evaluation", section 8, in Economy-wide Models and Development Planning. BLITZER et al. (eds.) (Oxford University Press).

BUENO, G.M., (1981). "Petroleo y Planes de Desarrollo en Mexico", Comercio Exterior, vol. 31, pp. 831-840.

BUITER, W.H. and D.D. PURVIS (1983). "Oil, Disinflation and Export Competitiveness: A Model of the Dutch Disease", in Monetary and Fiscal Policy with Flexible Exchange Rates, J. BHANDARI and H. PUTNAM (eds.) (Cambridge, MIT Press).

CARDOSO, E. and S. LEVY (1987). "Mexico". Chapter 16 in R. DORNBUSCH and L. HELMERS (eds.) The Open Economy, The World Bank, Washington D.C.

CASTANEDA, G., (1982). "Diversos Estudios Econometricos sobre la Demanda de Energia: El Caso de Mexico". BA Thesis, ITAM, Mexico.

CAVES, R.E. (1971). "Intertemporal Corporations: the Industrial Economics of Foreign Investment", Economica, 38, pp. 1-27.

CHAKRAVARTY, S. (1969). Capital and Development Planning. M.I.T Press, Cambridge, Mass.

CHAO, H., S. KIM, and A.S. MANNE (1982). "Computation of Equilibria for Nonlinear Economies: Two experimental models", Journal of Policy Modeling, vol. 4,pp. 23-43

CHENERY, H.B. (ed.) (1974). Redistribution with Growth. Oxford: Oxford University Press.

CHENERY, H.B. and H. UZAWA (1958). "Non-Linear Programming and Economic Development", in K.J. ARROW, L. HURWICZ and H. UZAWA (eds.) Studies in Linear and Non-Linear Programming (Stanford University Press, Stanford).

CHENERY, H.B., et al. (1974). Redistribution with Growth. Oxford University Press.

CHOE, B. (1978). "Energy Demand Prospects in Non-Opec Developing Countries", World Bank Working Paper.

CONDON, T., H. DAHL, and S. DEVARAJAN (1987). "Implementing a CGE Model on GAMS: The Cameroon Model", DRD. World Bank.

CORDEN, W.M. (1982). "Booming Sector and Dutch Disease Economics: a Survey", Working Papers in Economics and Econometrics No. 79. The Australian National University.

CORDEN, W.M. (1982a) "Exchange Rate Policy and the Resource Boom", Economic Record, 58, pp. 18-31.

CORDEN, W.M. and J.P. NEARY (1982). "Booming Sector and De-Industrialization in a Small Open Economy", Economic Journal 92, pp. 825-848.

CORDOBA, J. (1979). "Explotacion Optima de Reservas en un Contexto Macroeconomico", Documento No. 8, Banco de Mexico. Mexico.

CORREDOR, J. (1981). "El Significado Economico del Petroleo en Mexico", Comercio Exterior, vol 31, pp. 1311-1323.

CREMER, J. and M. WEITZMAN (1976). "Opec and the Monopoly Price of World Oil", European Economic Review, pp. 155-64.

DASGUPTA, P., A. SEN and S. MARGLIN (1972). Guidelines for Project Evaluation. (United Nations, New York).

DASGUPTA, P., R. EASTWOOD and G. HEAL (1978). "Resource Management in a Trading Economy", Quarterly Journal of Economics, pp. 297-306,

DASGUPTA, P., and G. HEAL (1974). "The Optimal Depletion of Exhaustible Resources", Review of Economic Studies, pp. 3-28.

-------, (1979). Economic Theory and Exhaustible Resources. Cambridge: Cambridge University Press.

DE ALBA, E. and R. SAMANIEGO (1985). "Estimacion de la Demanda de Gasolinas y Diesel y el Impacto de sus Precios sobre los Ingresos del Sector Publico". Documento VIII, El Colegio de Mexico. Mexico.

DERVIS, K., J. de MELO and S. ROBINSON (1982). General Equilibrium Models for Development Policy. (Cambridge University Press, Cambridge).

DERVIS, K., R. MARTIN and S. van WIJNBERGEN (1984). "Policy Analysis of Shadow Pricing, Foreign Borrowing and Resource Extraction in Egypt", World Bank Staff Working Papers. No. 622.

DEVARAJAN, S., and A.C. FISCHER (1981). "Hotelling's Economics of Exhaustible Resources Fifty Years Later" Journal of Economic Literature, 21, pp. 1045-1051.

DEVARAJAN, S. (1988). "Natural Resources and Taxation in Computable General Equilibrium Models of Developing Countries", Journal of Policy Modeling, pp. 505-528.

DIXIT, A., and D. NEWBERY (1984). "Setting the Price of Oil in a Distorted Economy", Economic Journal, 95, pp. 71-92.

DIXIT, A., and V. NORMAN (1980). Theory of International Trade. Cambridge: Cambridge University Press.

DORNBUSCH, R. (1987)."Overvaluation and Trade Balance". Chapter 5 in R. DORNBUSCH and L. HELMERS (eds.) The Open Economy. The World Bank, Washington D.C.

-------, (1988). "Mexico: Stabilization, Debt and Growth". M.I.T., mimeo.

DRUD, A., and W. GRAIS (1983). "Macroeconomic Adjustment in Thailand: Demand Management and Supply Conditions", Journal of Policy Modeling, pp. 207-232.

DRUD, A., W. GRAIS, and G. PYATT (1983). "The Transaction Values Approach to the Formulation and Implememntation of Economywide Equilibrium Models", DRD, World Bank. Washington, D.C.

-------, (1986). "Macroeconomic Modeling Based on Social Accounting Principles", Journal of Policy Modeling, pp. 111-145.

DULOY, J.H. and P.B. HAZELL (1975). "Substitution and Nonlinearities in Planning Models", in C.R. BLITZER, P.B. CLARK and L. TAYLOR (eds.) Economy-wide Models and Development Planning (Oxford University Press, Oxford).

DUNKERLEY, J. (1982). "Estimation of Energy Demand: The Developing Countries", Energy Journal.

EASTERLEY, W.R., (1985). "A Computable General Equilibrium Model of Mexico with Portfolio Balances: with aplication to devaluation". PhD. Thesis. M.I.T.

EASTWOOD, R.K. and A.J. VENABLES (1982). "The Macroeconomic Implications of a Resource Discovery in an Open Economy", Economic Journal, 92, 285-99.

FISCHER, B., E. GERKEN, and U. HIEMENZ (1982). Growth, Employment and Trade in an Industrializing Economy: A Quantitative Analysis of Mexican Development Policies. Kieler Studien, 170. Tubingen: J.C.B. Mohr.

FISCHER, D., et.al. (1975). "The Prospects for Opec: A Critical Survey of Models of the World Oil Market", Journal of Development Economics, 2, pp. 363-86.

GARCIA ALBA, P. (1986). "Especificacion de un Sistema de Demanda y su Aplicacion a Mexico",Estudios Economicos del Colegio de Mexico, Vol. 1, No. 2, pp. 305-335.

GELB, A.H. (1985a). "Adjustments to External Shocks: The Experience of Six Oil Exporters", Discussion Paper No. 94, DRD, World Bank.

GELB, A.H. (1985b) "The Impact of Oil Windfalls: Comparative Statics with an Indonesia-Like Model", Discussion Paper No. 133, DRD, World Bank.

GIL DIAZ, F. (1984). "Mexico's Path from Stability to Inflation", in A. HARBERGER (ed.), World Economic Growth, San Francisco: Institute for Contemporary Studies.

-------, (1985). "Changing Strategies", in Mexico and the United States: Studies in Economic Interaction, Boulder: Westview Press.

GINSBURGH, V. and S. ROBINSON (1984). "Equilibrium and Prices in Multisector Models", in M. SYRQUIN et al. (eds.) Economic Structure and Performance (Academic Press, Inc. London).

GOREUX, L.M. and A.S. MANNE (1973). Multilevel Planning: Case Studies in Mexico. (North-Holland, Amsterdam).

GRAIS, W. (1986). "Aggregate Demand and Macroeconomic Imbalances in Thailand: Simulations with the SIAM II Model", Journal of Development Economics.

GRIFFIN, J.M. (1985). "Opec Behavior", American Economic Review, pp. 954-963.

GRUEN, F., and W. CORDEN (1970). "A Tariff that Worsens the Terms of Trade", in A. McDOUGALL and R. SNAPE (eds.) Studies in International Economics: Monash Conference Papers, Amsterdam, North-Holland, pp. 55-8

HANSEN, R. (1971). The Politics of Mexican Development, Baltimore: John Hopkins University press.

HEAL, G.M. (1973). The Theory of Economic Planning. Amsterdam: North-Holland.

-------, (1975). "Aspects of Natural Resource Depletion", in The Economics of Natural Depletion, D.W. PEARCE (ed.) (New York: Wiley).

HITCH, C. (ed.) (1977). Modeling Energy-Economy Interactions: Five Approaches. Washington, D.C.: Resources for the Future.

HELMERS, L. (1987). "The Real Exchange Rate". Chapter 2 in R. DORNBUSCH and L.HELMERS (eds.). The Open Economy. The World Bank, Washington D.C.

HOGAN, W. and A.S. MANNE (1977). "Energy-Economy Interactions The Fable of the Elephant and the Rabbit?", in Modeling Energy-Economy Interactions: Five Approaches. C. HITCH (ed.) pp. 247-277.

HOTELLING, H. (1931). "The Economics of Exhaustible Resources", Journal of Political Economy, 39, pp. 137-175.

HUDSON, E.A. and D.W. JORGENSON (1974). "U.S. Energy Policy and Economic Growth", Bell Journal of Economics, pp. 461-484.

HUGHES, G. (1986a). "The Impact of Fuel Taxes in Tunisia", mimeo, Department of Economics, University of Edinburgh.

-------, (1986b). "A New Method for Estimating the Effects of Fuel Taxes: An Application to Thailand", World Bank Economic Review, pp. 665-701.

INEGI-CONAPO (1985). Proyecciones de la Poblacion de Mexico y de las Entidades Federativas, SPP, Mexico.

JOHANSEN, L. (1960). A Multisectoral Study of Economic Growth. (North-Holland, Amsterdam).

JONES, H. (1984). An Introduction to Modern Theories of Economic Growth. The Camelot Press, England.

JONES, R.W. (1986). "The Dutch Disease: A Trade Theoretic Perspective". Comments on "Natural Resources and the Macroeconomy: A Theoretical Framework" by J.P. NEARY and S. van WIJNBERGEN. In Natural Resources and the Macroeconomy, edited by J.P. NEARY and S. van WIJNBERGEN, pp. 46-50.

JONES, R.W., J.P. NEARY and F. RUANE (1983). "Two-Way Capital Flows: Cross-Hauling in a Model of Foreign Investment", Journal of International Economics, 13, pp. 357-66.

KALYMON, B.A. (1975) "Economic Incentives in Opec Oil Pricing". Journal of Development Economics, pp. 337-362.

KEHOE, T.J. and J.J. SERRA PUCHE (1982). "A General Equilibrium Analysis of Energy Policy in Mexico", mimeo, (MIT, Cambridge, MA).

KENDRICK, D., and A. MEERAUS (1985). "GAMS: An Introduction". DRD, World Bank.

KENNEDY, M., (1974). "An Economic Model of the World Oil Market", Bell Journal of Economics, 5, pp. 540-577.

KIM, M.S. (1986a). "Industrial Development in Mexico: Problems, Policy Issues, and Perspectives".

-------, (1986b). "Models of Energy-Economy Interactions for Developing Countries: A Survey". The Journal of Energy and Development, pp. 141-165.

LAU, L.J. (1984). "Comments", in H. SCARF and J. SHOVEN (eds.), Applied General Equilibrium Analysis (Cambridge University Press).

LESSARD, D., and J. WILLIAMSON (eds.) (1987). Capital Flight and Third World Debt, Washington D.C.: Institute for International Economics.

LEVY, W.J. (1974). "Implications of World Oil Austerity", Journal of Development Economics.

LEWIS, S.R.,Jr. (1984). "Development Problems of the Mineral Rich Countries", in M. SYRQUIN et al (eds.) Economic Structure and Performance (Academic Press, Inc, London).

LIZONDO, S. (1987). "Exchange Rate Differential and Balance of Payments under Dual Exchange Makets", Journal of Development Economics, 26, pp. 37-53.

LLUCH, C., A.A. POWELL and R.A. WILLIAMS (1977). Patterns in Household Demand and Saving. (Oxford University Press, Oxford).

LOONEY, R.E. (1985). Economic Policymaking in Mexico: Factors Underlying the 1982 Crisis. Durham: Duke University Press.

LOUCKS, D. (1975). "Planning for Multiple Goals", in C.R. BLITZER et. al. (eds.) Economy-Wide Models and Development Planning, pp. 213-33.

de LUCIA, R. and H. JACOBY (1982). Energy Planning for Developing countries: A Study of Bangladesh. Baltimore: Johns Hopkins University Press.

LUSTIG, N., B. GIBSON, and L. TAYLOR (1986). "Terms of Trade and Class Conflict in a Computable General Equilibrium Model for Mexico", The Journal of Development Studies, 23, pp. 40-59.

MACRAKIS, M. (ed.) (1974). Energy Demand, Conservation, and Institutional Problems. Cambridge: M.I.T. Press.

MALINVAUD, E. (1977). The Theory of Unemployment Reconsidered. (Oxford University Press, Oxford).

MANNE, A.S. (1963). "Key Sectors of the Mexican Economy, 1960-1970", Ch. 16 in A.S. MANNE and H.M. MARKOWITZ (eds.) Studies in Process Analysis (New York: Wiley).

MANNE, A.S. (1973). "Dinamico, a Dynamic, Multisector, Multi-Skill Model", in L. GOREAUX and A.S. MANNE (eds.) Multilevel Planning: Case Studies in Mexico (North-Holland, Amsterdam), pp. 107-150.

MANNE, A.S. (1974). "Multisectoral Models for Development Planning: A Survey", Journal of Development Economics, pp. 43-69.

-------, (1976). "ETA-Macro: A Model of Energy- Economy Interactions", in Modeling Energy-Economy Interactions: Five Approaches. C HITCH (ed.) pp. 1-45

-------, and P.V. PRECKEL (1984). "North-South Trade, Capital Flows, and Economic Growth: An Almost Neoclassical Model", in M. SYRQUIN et. al. (eds.) Economic Structure and Performance. (Academic Press, Inc., London).

MANSUR, A., and J. WHALLEY (1984). "Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration, and Data", in H. SCARF and J. SHOVEN (eds.), Applied General Equilibrium Analysis (Cambridge University Press).

MARCONI, Y. (1967). "Mexico's Economic and Financial Record", Board of Governors of the Federal Reserve Staff Economic Studies, No. 23.

MARQUEZ, J. (1986). "Oil-Price Effects in Theory and Practice". Journal of Development Economics, pp. 1-27.

MARTIN, R., and S. van WIJNBERGEN (1986). "Shadow Prices and the Intertemporal Aspects of Remittances and Oil Revenues in Egypt", pp. 143-168.

MEERAUS, A. (1983). "An Algebraic Approach to Modeling", Journal of Economic Dynamics and Control, pp. 81-108.

MURTAGH, B., and M. SAUNDERS (1983). MINOS 5.0 User's Guide. Technical Report. SDL83-20, Standford University.

NAVARRETE, I. (1970). "La Distribucion del Ingreso y el Desarrollo Economico de Mexico", in El Perfil de Mexico en 1980, Mexico: Siglo XXI, pp. 15-68.

NEARY, J.P. (1984). "Real and Monetary Aspects of the 'Dutch Disease'", in D.C. HAGUE and K. JUNGENFELD (eds) Structural Adjustment in Developed Open Economies, London: Macmillan.

NEARY, J.P., and D.D. PURVIS (1983). "Real Adjustment and Exchange Rate Dynamics", in J. FRENKEL (ed.) Exchange Rates and International Macroeconomics, Chicago: Chicago University Press.

NEARY, J.P., and S. van WIJNBERGEN (1986a). Natural Resources and the Macroeconomy. Basil Blackwell, Oxford.

NEARY, J.P., and S. van WIJNBERGEN (1986b). "Natural Resources and the Macroeconomy: a theoretical framework", in J.P. NEARY and S. van WIJNBERGEN (eds) Natural Resources and the Macroeconomy, pp. 13-45.

NORDHAUS, W.D. (1973). "The Allocation of Energy Resources", Brookings Papers of Economic Activity, 4, no. 3, p. 529-76.

ORTIZ, G. and J.J. SERRA PUCHE (1986). "A Note on the Burden of the Mexican Foreign Debt", Journal of Development Economics, 21, pp. 111-129.

ORTIZ MENA, A. (1970). "Desarrollo Estabilizador", El Trimestre Economico, No. 146.

ORTIZ MENA, A., V. URQUIDI, et al. (1953). El Desarrollo Economico de Mexico y su Capacidad para Absorber Capital del Exterior, Mexico: Nacional Financiera.

PETROLEOS MEXICANOS. Memoria de Labores, various years. Mexico: Pemex.

PHELPS, E.S. (1963). "Substitution, Fixed Proportions, Growth and Distribution", International Economic Review.

POWELL, A. (1974). Empirical Analytics of Demand Systems, Lexington Books.

PRECKEL, P.V. (1985). "Alternative Algorithms for Computing Economic Equilibria", Mathematical Programming Study, 23, pp. 163-172.

PYATT, G., and A. ROE with J. ROUND and others (1977). Social Accounting for Development Planning: With Special Reference to Sri Lanka, Cambridge: Cambridge University Press.

PYATT, G. and J.I. ROUND (eds.) (1985). Social Accounting Matrices: A Basis for Planning. The World Bank, Washington, D.C.

PYATT, G. and E. THORBECKE (1976). Planning Techniques for Better Future, Geneva: International Labour Office.

PYATT, G. (1987). "The SAM Approach in Retrospect and Prospect", University of Warwick Economics Research Paper No. 290.

-------, (1988). "A SAM Approach to Modeling", Journal of Policy Modeling, pp. 327-352.

PYNDICK, R.S. (1978). "Gains to Producers from the Cartelization of Exhaustible Resources", The Review of Economics and Statistics, pp. 238-51.

REYES-HEROLES, J. (1983). Politica Macroeconomica y Bienestar en Mexico. Mexico: Fondo de Cultura Economica.

-------, (1988). "Multi-Mini-Menu: Elementos para Avanzar en la Solucion del Problema de la Deuda Externa de Mexico", mimeo, DGPH, SHCP, Mexico, D.F.

ROE, A., and S. PAL (1986). "Adjustment to Oil Shocks in Kenya: 1972-1982", University of Warwick. Discussion Paper 76.

ROS, J. (1986). "Mexico from the Oil Boom to the Debt Crisis. An Analysis of Policy Responses to External Shocks 1978-1985", in R. THORP, and L. WHITHEAD. The Latin American Debt Crisis. London: MacMillan.

SECRETARIA de HACIENDA y CREDITO PUBLICO (1986a). "Mexico: Development Financing Strategy", mimeo, DGPH, Mexico, D.F.

-------, (1986b). "Mexico: Main Economic Issues", mimeo, DGPH, Mexico, D.F.

SECRETARIA de PATRIMONIO y FOMENTO INDUSTRIAL (1979). Plan Nacional de Desarrollo Industrial. Mexico.

SECRETARIA de PROGRAMACION y PRESUPUESTO (1979). La Industria Petrolera en Mexico. INEGI, Mexico.

-------, (1985a). La Industria Petrolera en Mexico. INEGI, Mexico.

-------, (1985b). 10 Anos de Indicadores Economicos y Sociales de Mexico. INEGI, Mexico.

-------, (1986a). X Censo General de Poblacion y Vivienda 1980. INEGI, Mexico.

-------, (1986b). Matriz de Insumo Producto 1980. INEGI, Mexico.

-------, (1987). Encuesta Nacional de Ingresos y Gastos de los Hogares: 1983-84. Mexico.

SECRETARIA del TRABAJO y PREVISION SOCIAL (1977). Proyecciones de Poblacion Economicamente Activa para la Republica Mexicana. Serie Avances de Investigacion, 4 Mexico: CENIET.

SERRA-PUCHE, J.J. (1983). "A General Equilibrium Model for the Mexican Economy", in Applied General Equilibrium Analysis, edited by H. SCARF and J.B. SHOVEN (Cambridge University Press, Cambridge).

SHOVEN, J., and J. WHALLEY (1984). "Applied General Equilibrium Models: A Survey", Journal of Economic Literature, 24, pp. 1024-1049.

SIDAOUI, J. (1979). "Factor Market Distortions in a Multisectorial Model: A Case Study of Mexico", PhD Thesis, George Washington University, Washington, D.C

SILVA HERZOG, J. (1980). De la Historia de Mexico, 1810-1938: Documentos Fundamentales, Ensayos y Opiniones, Mexico: Siglo XXI.

SOLIS, L. (ed.) (1973). La Economia Mexicana, Mexico: Fondo de Cultura Economica.

-------, (1981). Economic Policy Reform in Mexico: A Case Study for Developing Countries, New York: Pergamon.

-------, and D. BROTHERS (1966). Mexican Financial Development, Texas University Press.

SOLOW, R.M. (1974) "Intergenerational Equity and Exhaustible Resources", Review of Economic Studies, pp. 29-45.

STIGLITZ, J.E. (1974). "Growth with Exhaustible Natural Resources", Review of Economic Studies, pp. 46-60.

STONE, R. (1973). "A System of Social Matrices", The Review of Income and Wealth, Serie 19, 2 (June).

SYRQUIN, M. (1974). "Production Functions and Regional Efficiency in the Manufacturing Sector in Mexico, 1965". PhD Thesis, Harvard University. Cambridge MA.

TAYLOR, L. (1975). "Theoretical Foundations and Technical Implications", in C.R. BLITZER et. al. (eds.) Economywide Models and Development Planning.

TELLEZ, L. (1986). "Essays of an Open Economy: The Case of Mexico", PhD Thesis, M.I.T., Cambridge, Mass.

THORBECKE, E. (1986). "The Social Accounting Matrix and Consistency-Type Planning Models", in Social Accounting Matrices: A Basis for Planning, edited by G. PYATT and J.I. ROUND. The World Bank.

TREJO, S. (1973). Industrializacion y Empleo en Mexico, Fondo de Cultura Economica, Mexico.

TURLINGTON, E. (1930). Mexico and Her Foreign Creditors, New York: Columbia University Press.

UNITED NATIONS (1968). A System of National Accounts. Department of Economic and Social Affairs Studies in Methods, Series F, No. 2, Rev. 3. New York.

de URQUIJO, L. (1985). "Las Politicas de Ajuste en el Sector Externo: Analisis en un Modelo Computable de Equilibrio General para la Economia Mexicana", Documentos de Trabajo, El Colegio de Mexico, VI.

VERNON, R. (1963). The Dilemma of Mexico's Development: The Role of the Private and Public Sectors. Cambridge: Harvard University Press.

WIJESINGHE, D.S. (1983). "Some Experiments with a Multisectoral, Intertemporal Optimization Model for Sri Lanka", Ph.D. Dissertation, University of Warwick.

van WIJNBERGEN, S. (1984a). "Inflation, Employment and the Dutch Disease in Oil Exporting Countries: A Short-run Disequilibrium Analysis", Quarterly Journal of Economics. pp. 233-250.

-------, (1984b). "The 'Dutch Disease': A Disease After All?", Economic Journal 94, pp. 41-55.

WILLARS, J.M. (1984). "The Mexican Hydrocarbons Sector: Models, Policy Issues and Perspectives". PhD Thesis. Cornell University.

WIONCZEK, M.S. (1987). "Energy Planning and Oil in Mexico: The Outstanding Issues in Historical Persective", in The Economics of Choice Between Energy Sources, edited by P. MAILLET et al. (MacMillan Press, London).

WOLF, C., D. RELLES and J. NAVARRO (1981). "Oil and Energy Demand in Developing Countries in 1990". Energy Journal.

WORLD BANK (1987). Mexico After the Oil Boom, Washington, D.C.

ZEDILLO, V.E. (1979). "Extraccion Optima de Petroleo y Endeudamiento Externo: El Caso de Mexico." Documento No. 10, Banco de Mexico.

-------, (1985). "The Mexican External Debt: The Last Decade", in M. WIONCZEK (ed.) Politics and Economics of the External Debt Crisis, Boulder: Westview Press.

-------, (1987). "Case Studies: Mexico", in D. LESSARD and J. WILLIAMSON (eds.) Capital Flight and Third World Debt. Washington D.C. Institute for International Economics.